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*S^r Philip Touchet Chetwode
of Oakley Staffordshire Bar.^t*

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THE
Young Gentleman's
ASTRONOMY,
CHRONOLOGY,
AND
DIALLING,

Containing such
ELEMENTS of the
said Arts or Sciences, as are most
useful and easy to be known.

By EDWARD WELLS, D. D.
Rector of Cotesbach in Leicestershire.

The Second Edition.

LONDON:

Printed for James Knapton, at the Crown
in St. Paul's Church-Yard. 1718.

THE
ROYAL COLLEGE OF

PHYSICIANS
IN GENERAL

OF GREAT BRITAIN
AND IRELAND

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YOUNG GENTLEMAN

AND HIS SERVANTS

BY J. H. B. B. B.

IN TWO VOLUMES

THE FIRST VOLUME

THE SECOND VOLUME

THE THIRD VOLUME

THE FOURTH VOLUME

THE FIFTH VOLUME

THE SIXTH VOLUME

THE SEVENTH VOLUME

THE EIGHTH VOLUME

THE NINTH VOLUME

THE TENTH VOLUME

THE ELEVENTH VOLUME

THE TWELFTH VOLUME

THE PREFACE.

THERE are two Ends of writing Books, which relate to the several Parts of Learning: one to advance Learning it self; the other to assist Learners.

In pursuance of the former, the Capaciousness of the Subject is chiefly to be considered; and nothing is to be omitted, which properly falls within the Compass of the Art or Science treated of. In pursuance of the latter, the Capacities of the Learners are principally to be regarded; and notice is to be taken, not of whatever may be known or done by the Art or Science treated of, but only of what is most useful, and withal easy to be known.

Besides, Regard is to be had, as to the Capacities principally, so secondarily to the Circumstances of the Young Students. As for those who are to make their Fortunes by their Learning, more Particulars are requisite to be known, and consequently more Pains are requisite to be taken by such, than by others; who, being born to plentiful Estates, are by their Learning

The Preface.

not to make, but to adorn their Fortunes already made.

And there is the more Need of this distinct Consideration, because one of the first Things Young Gentlemen become sensible of, is this; that they are not under a Necessity of taking Pains for their Livelihood. Which has such an Influence upon them, as that they are apt not to relish any Part of Learning, which requires more than ordinary Pains or Application of Mind. And indeed to expect they should act otherwise, is in effect no other, than to expect gray Hairs upon young Heads.

Wherefore, the most proper Method to make Young Gentlemen Learned, is this; to teach them at first only such Elements of the liberal Arts or Sciences, as are most useful in the common Affairs of Life, and withal most easy to be known. They have a competent Apprehension of the Usefulness of such Things as occur in the common Concerns of Life; and consequently hereby that Question frequently put by Young Students, of what Use is this? will be answered afore-hand, and so they will be rendered willing to understand what they apprehend the Use of. And when they find that the Understanding thereof carries in it no Difficulty, then they will be also encouraged to proceed. And when they have thus gone through, and become
Masters

The Preface.

Masters of the most useful and easy Elements of the liberal Arts and Sciences, they will thereby be enabled with much more Ease to conquer the more difficult Parts of Learning, if their own Inclinations shall lead them thereto hereafter, when they are come to Riper Years, and so can judge more rightly of the worth of Learning.

On these Considerations, and with this View it was, that I drew up this Astronomical Treatise, and gave it the Title of the Young Gentleman's Astronomy; Such Astronomical Treatises as were afore extant among us; either treating only of the Doctrine of the Sphere or Globe, or else taking in several Particulars of the other Part of Astronomy, too difficult for, and not necessary to be known by Young Gentlemen.

It only remains to be observed, that I suppose Young Gentlemen to proceed regularly in their Studies, and therefore to have learned Arithmetick and Geometry, before they enter upon Astronomy: as also, that such Particulars, as were not necessary to my present Design, and yet seemed too material to be quite omitted; I have added by way of Annotations, both in this Treatise, and the others of Chronology and Dialling.

THE

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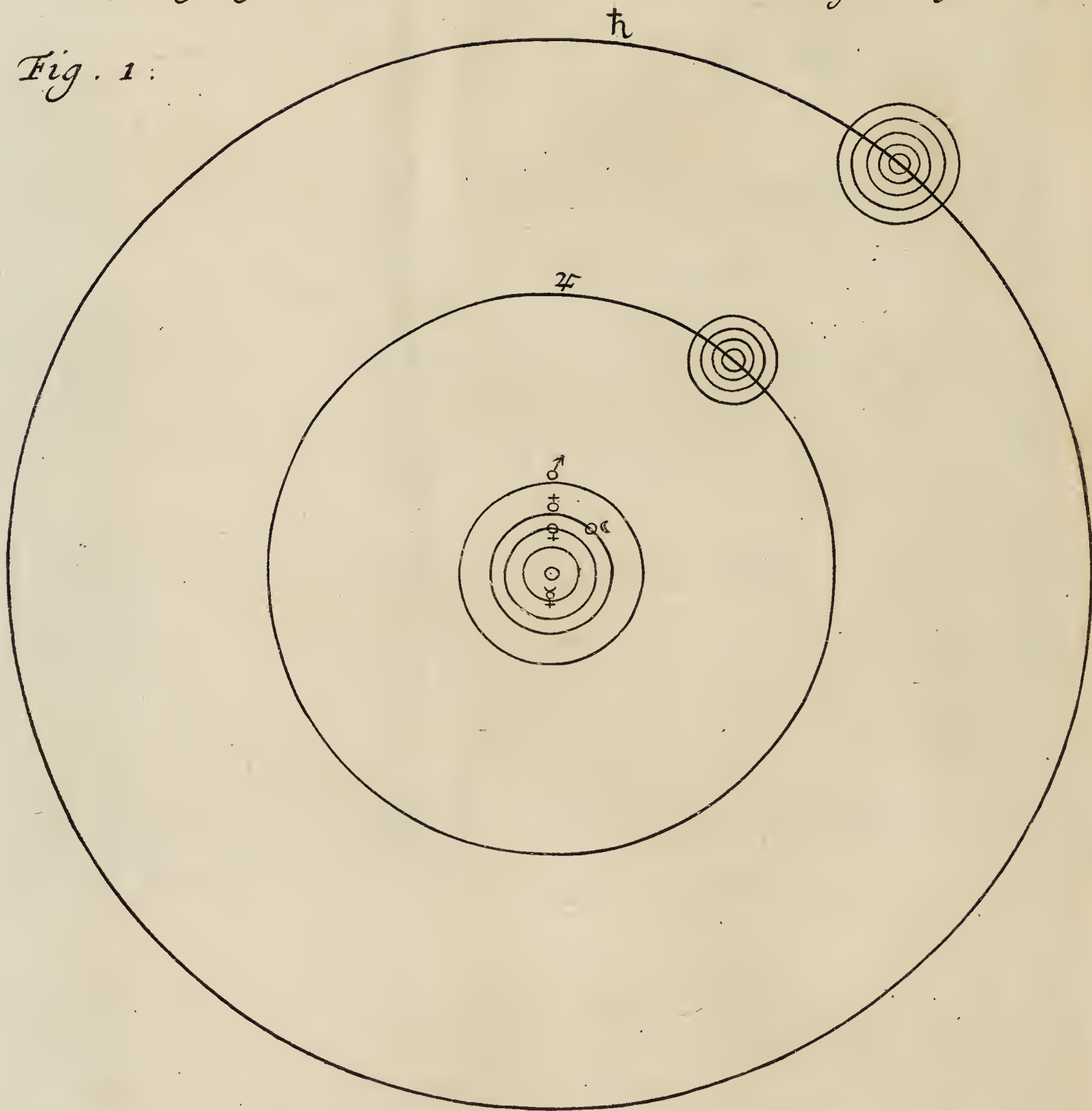
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THE

Place this facing Pag. 1.

Astronomy. Plate 1.

Fig. 1.



THE
Young Gentleman's
ASTRONOMY.

The INTRODUCTION.

WE are informed by ^{I.}
Moses in his Sacred ^{The Cele.}
History of the Crea- ^{stial Lights}
tion, that God *made* ^{made to}
^{what Ends.}
Lights in the () wide*
Space of Heaven, to give Light upon the
Earth, and to divide the Day from the
Night, and to be for Signs and for Seasons,
and for Days and Years, Gen. 1. 14.—18.

(*) So the Hebrew Word *Rakian* truly signifies.
It is rendered in our English Bible the *Firmament*, in
Conformity to the Septuagint Version.

B

The

2. The principal Way, whereby the All-wise Creator of the World has rendered the Celestial Lights subservient to the fore-mentioned Ends, is by certain established Laws of *Motion*; according to which, they either *really* move themselves, or at least *seem* to us to move.

The Celestial Lights are made subservient to the Ends, for which they were created, principally by Motion.

3. What these Laws of Motion are, the Divine Wisdom has not thought fit to reveal unto us. Wherefore, all that we can do, is to make probable Conjectures concerning them. Such Conjectures are termed (†) *Hypotheses*, i. e. Suppositions; because it cannot be positively affirmed of the most probable Conjecture, that the Celestial Lights do so move; but only, that it is reasonable to *suppose*, they move so, rather than any other Way; and that upon such a Supposition, their (||) *Phænomena* (or Appearances) may be rationally solved or explained.

We can only make probable Conjectures concerning the Laws of their Motion; which Conjectures are called Hypotheses, and why.

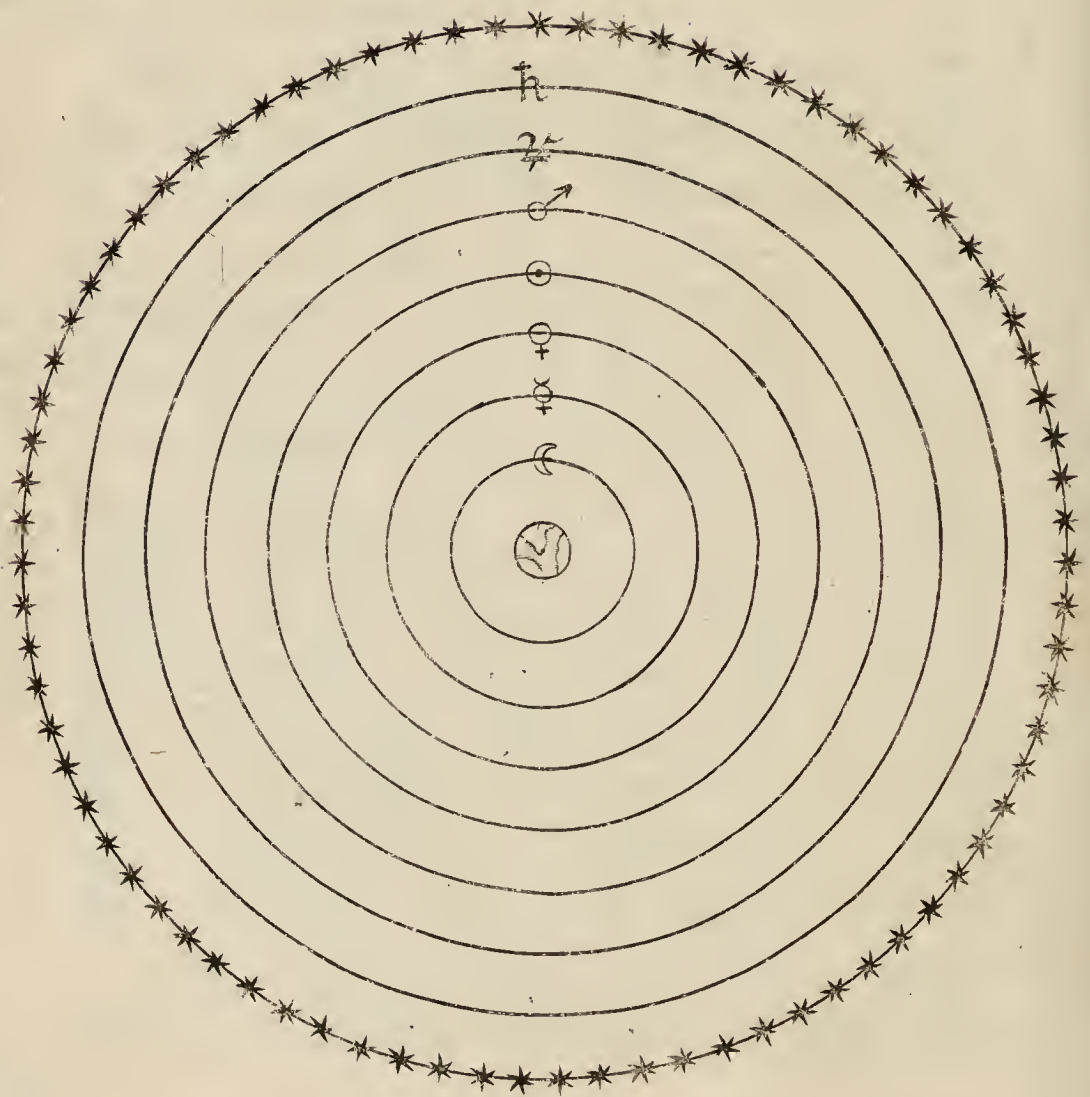
4. The Explanation of these Hypotheses, and the Solution of the Astronomy, *what.*

(†) It is a *Greek* Word, derived from the Verb *ὑποτίθημι* to suppose.

(||) It is a *Greek* Word also, derived from the Verb *φαίω* to appear.

Place this facing Pag. 3.

Fig. 2.



The Introduction.

3

lestial *Phænomena* thereby, is what makes up the Science called (*) *Astronomy*: which is a *Greek* Word originally, and denotes in that Language the Doctrine or Knowledge of the *Laws*, or of the *Distribution* and *Situation* of the Stars, or Celestial Lights.

There are four more remarkable Hypotheses, the (†) *Ptolemaick*, the *Copernican*, the *Tychonick*, and the *Semi-tychonick*. Of these the *Coperni-*
5. *The Copernican Hypothesis; why the most Probable.*
can

(*) This Word may be derived, as to its latter Component, either from νόμος a *Law*, or from νομός a *Distribution, Seat, or Situation*.

(†) The *Ptolemaick* Hypothesis is so called from *Claudius Ptolemæus*, a famous Mathematician of *Pelusion* in *Egypt*, who lived in the former Part of the second Century after Christ, under the *Roman* Emperours *Adrian* and *Antoninus Pius*. He writ both of *Astronomy* and *Geography*; and by his *Astronomical* Writings was conveyed to succeeding Ages, the Hypothesis which goes under his Name, and which was generally, not to say universally, received in these Parts of the World till the Days of *Copernicus*. The Order of the Celestial Lights as to their Situation, according to this Hypothesis, is represented *Fig. 2*. But since by the Help of *Telescopes*, the *Phæses* of *Venus* and *Mercury* have been discovered, this Hypothesis is rejected, as not consistent therewith. I pass by the *Epicycles*, and several other Particulars justly blamable in this Hypothesis.

Copernicus, who was Born in 1473 at *Tborn*, a Town of Polish *Prussia*, perceiving the several Exceptions

The Introduction.

can is now generally received by the more learned in *Astronomy*, as the most probable Hypothesis: forasmuch as it not only agrees with the Celestial *Phænomena*, but also explains the Motions

that the *Ptolemaick* Hypothesis was justly liable to, not only revived the old Hypothesis of *Philolaus*, (which Cardinal *Cusa* had moved and defended sometime before him,) but also went so far as to illustrate how the Celestial *Phænomena* might be very well solved thereby; insomuch that this Hypothesis began presently after to be embraced by many, if not by most, of the more Learned *Astronomers*, and from the principal Reviver of it, *Copernicus*, to be called the *Copernican* Hypothesis. The Explication of this takes up great Part of this Treatise. To this belongs *Fig. 1.*

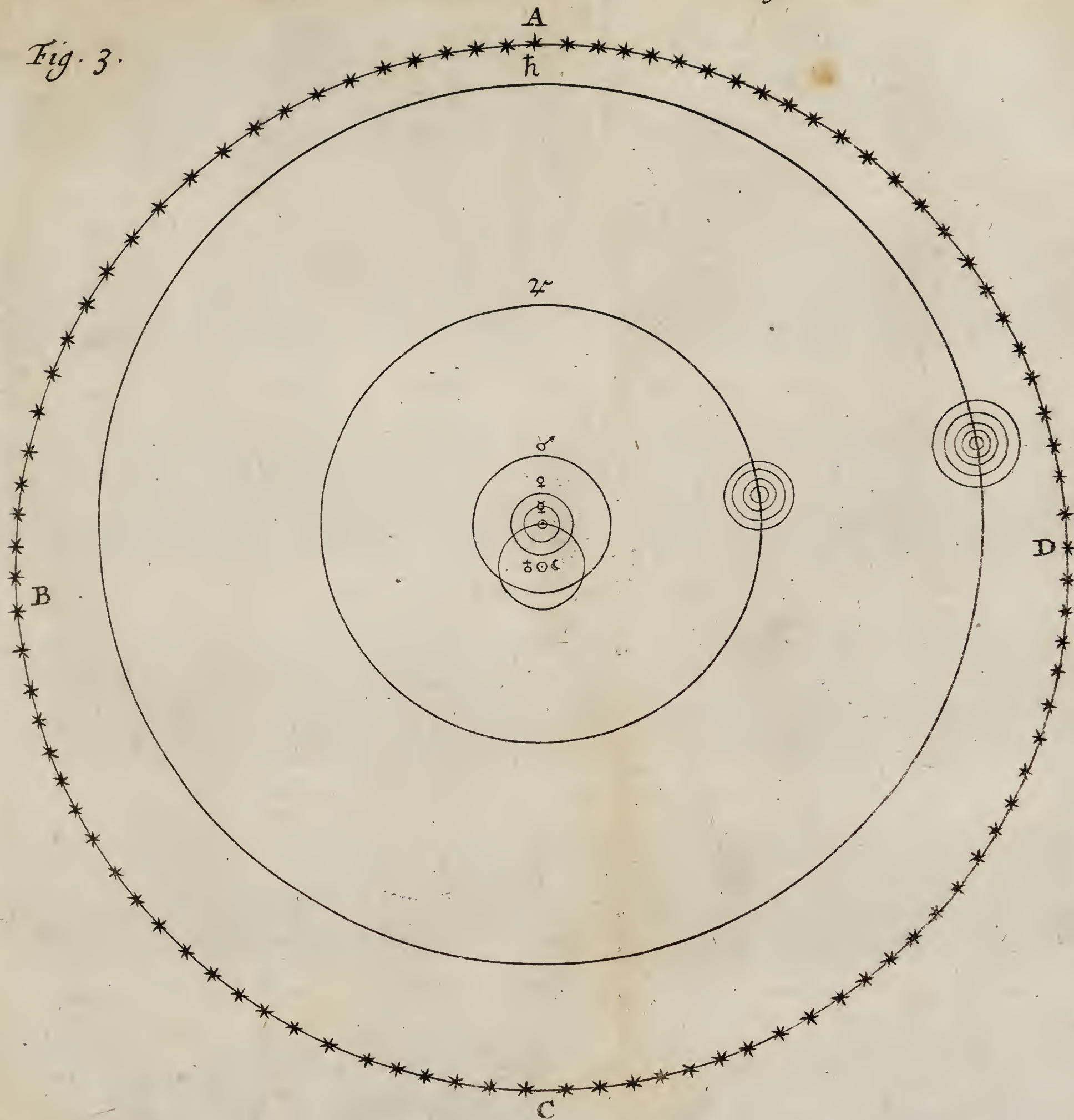
The *Tychonick* Hypothesis is so called from *Tycho Brahe*, a noble Dane, who lived in the latter part of the sixteenth Century, and is famous for his Astronomical Observations at *Uraniburg*, (a Castle built by him in the Island *Weer* or *Huena* in Denmark, and by him called by this Name, as importing the Tower or Castle of Heaven.) This great Person and Astronomer, though he approved of the *Copernican* Hypothesis in rejecting the Epicycles, and other superfluous and erroneous Particulars of the *Ptolemaick* Hypothesis, yet could not reconcile himself to the Motion of the Earth, and the Sun's standing still, both asserted by *Copernicus*. Hereupon he set himself to contrive a new Way for solving the Celestial *Phænomena*, whereby he might avoid what was culpable in the *Ptolemaick* Hypothesis, and yet still retain the Motion of the Sun round the Earth, as round the Center of the World. To this his Hypothesis appertains, *Fig. 3.*

The *Semi-tychonick* Hypothesis is so stiled, as agreeing with the *Tychonick*, excepting only in this, that
whereas,

Place this facing Pag. 4.

Astronomy Plate 3

Fig. 3.





The Introduction.

5

tions whence the said *Phænomena* arise, after the most (||) simple and uniform Manner, and consequently after such a Manner as is most agreeable to the infinite Wisdom of the Creator. I proceed therefore to shew, how the Celestial *Phænomena*, at least the more remarkable of them, may be solved according to this Hypothe-

whereas the *Tychonick* makes the Earth to have no Motion at all, the *Semi-tychonick* makes it to move round its own *Axis*, and so agrees therein with the *Copernican*. But though the *Tychonick* and *Semi-tychonick* Hypothesis were both designed as Corrections of the *Copernican*, yet the Generality of the more Learned in *Astronomy* do still prefer the *Copernican* as the most probable, and that for the Reason above mentioned in short, and to be more largely insisted on and explained in the Annotations next following.

(||) These two Propositions, *viz. Frustrà fit per plura, quod fieri potest per pauciora*; and *Natura nihil agit frustrà*, being so evident to Reason, as by Logicians and Philosophers to be esteemed *Axioms*, i. e. unquestionable Truths; it hence follows, that That Hypothesis is to be esteemed most agreeable to the Wisdom of God, the Author of Nature, which explains the Motions whence the Celestial *Phænomena* arise, after the most simple (or uncompounded) and uniform Manner; that is, which adjusts the said Motions to the fewest Laws and Principles. But herein the *Copernican* Hypothesis excels all the rest, forasmuch as according thereto, all the Bodies, on whose Motion depend the Celestial *Phænomena*, are retained in their proper *Orbits* by the single Principle of Gravity, and move in their *Orbits* according to one general Rule, or Law of Motion. Of which see more in *Chap. 1.*

The Introduction.

sis. And in order hereunto it will be requisite to begin with laying before the Reader the *Copernican* (*) *System*, i. e. in what Order the several Bodies, whereon depend the Celestial *Phænomena*, are placed with Respect one to the other, according to this Hypothesis.

(*) The Word *System* is borrowed from the *Greek* Tongue, wherein it denotes that Frame or Model which arises from placing several Things together, it being a Derivative of the Verb *συνίστημι* to put or place together.

C H A P.

C H A P. I.

Of the Copernican System in general.

TH E Copernican System is represented, *Fig. 1.* where the Sun ^{I.} *The Place of the Sun.* is placed in the Center, and supposed never to move out of it, but only to move therein round its own (*) *Axis*, from West to East, in the Space of about 25 Days. This Motion of the Sun round its *Axis* is inferred from the Observations made of the Spots of the Sun.

Round the Sun, as the Center of ^{2.} *The Place of Mercury, Venus, the Earth, Mars, Jupiter, and Saturn; and their Periodical Times.* their *Orbits*, move six Spherical Bodies in this Order and Time, *viz.* *Mercury* next to the Sun, in about three Months; *Venus* next to *Mercury*, in about seven Months and an Half; after that the *Earth* in a Year; then *Mars* in about two Years; then *Jupiter* in twelve Years; and outermost

(*) See *Chap. 5. Sect. 5.* and the Note there.

Of the Copernican

of all *Saturn* in about thirty Years. These are respectively denoted, *Fig.* 1. by their proper Characters.

3
Of the
Moon, and
the Satel-
lites of
Jupiter
and Sa-
turn.

As the fore-mentioned six Bodies move round the *Sun*, so round three of them move other Bodies; *viz.* round the Earth moves the *Moon* in about 27 Days, 8 Hours; round *Jupiter* move four, and round *Saturn*. move five Bodies, called respectively the (†) *Satellites* of *Jupiter* and *Saturn*. Of the *Satellites* of *Jupiter*, the innermost moves round *Jupiter* in 1 Day, 18 Hours; the second in 3 Days, and a little more than Half a Day; the third in 7 Days, 4 Hours; the fourth and outmost in sixteen Days, 18 Hours. Of the *Satellites* of *Saturn*, the inmost moves round *Saturn* in 1 Day, 21 Hours; the second in 2 Days, 18 Hours; the third in 4 Days, and a little more than half a Day; the fourth in almost 16 Days; and the fifth in 79 Days, 8 Hours.

(†) They are so called, as attending *Jupiter* and *Saturn*, as a Prince is attended by his *Satellites* or Life-guard.

System in general

9

All the Bodies afore-mentioned, except the *Sun*, are called (||) *Planets*, ^{Planets, why so called, and why distinguished into Primary and Secondary.} 4
(which Word in the *Greek Language* denotes *Wanderers*) forasmuch as never keeping for any Time the same Distance or Situation one to the other, they may be said to be always Straggling or *Wandering* from one another, And because the *Moon* and the *Satellites* of *Jupiter* and *Saturn* are Planets of Planets, hence they are distinguished by the Name of *secondary Planets*, and the other six Planets agreeably thereto are distinguished by the Name of *primary Planets*.

The Distance of the primary Planets from the *Sun*, is much the same ^{5 The Distance of the primary Planets from the Sun.} as is expressed, *Fig. 1.* For dividing the Distance of the *Earth* from the *Sun* into ten Parts, the Distance of *Mercury* from the *Sun* is almost four such Parts, of *Venus* seven, of *Mars* fifteen, of *Jupiter* fifty-two, and of *Saturn* ninety-five.

(||) Whereas the Planets are commonly reckoned seven, this is according to the *Ptolemaick System*, *Fig. 2.*

And

6.

The Distance of the secondary Planets from their Primary.

And as to the Distance of the secondary Planets from their primary respectively, it is esteemed to be such as this; *viz.* the Distance of the Moon from the Earth to be about 60 Semi-diameters of the Earth. The inmost *Satelles* of *Jupiter* is esteemed to be distant $5\frac{2}{3}$ Semi-diameters of *Jupiter* from the Center of *Jupiter*; the second *Satelles* is esteemed to be distant 9 of the same Semi-diameters; the third $14\frac{1}{3}$ such Semi-diameters; and the fourth $25\frac{1}{2}$ Semi-diameters. In like manner the Distance of the inmost *Satelles* of *Saturn* from the Center of *Saturn* is reckoned to be $4\frac{1}{4}$ Semi-diameters of *Saturn*; the distance of the second to be $5\frac{3}{5}$ such Semi-diameters; of the third, 8 Semi-diameters; of the fourth, 18; of the fifth, 54 Semi-diameters of *Saturn*.

7.

The Motion of all the Planets is regulated after an uniform Manner.

The Reason of taking such particular Notice of the Distance of the primary Planets from the Sun, and of the secondary Planets from their respective Primary, is this, *viz.* because these several Distances (as well as the several Times, wherein the Planets, whether Primary or Secondary, move round their respective Orbits, and which

System in general.

II

which are therefore stiled their *Periodical Times*) are requisite to be known, for the apprehending the Excellency of the *Copernican System*; according to which the Motion of all the Planets, both Primary and Secondary, are regulated by one general Law, which is this:

The Squares of the Periodical Times of the { Primary } Planets are one to another, as the Cubes of their Distances from the { Sun. Center of the Primary.

Thus for Instance as to the primary 8. Planets, the Period of *Saturn* is (ro- The same exemplified as to the primary Planets. *tundè*) 30 Years, of *Jupiter* 12; the Squares of which Numbers are 900 and 144. The Distance of *Saturn* from the Sun is found by Observation to be to the Distance of *Jupiter* from the Sun as about (*) 9 to 5, the Cubes of which are 729 and 125. But the Squares 900 and 144 are very nearly in the same *Ratio*, as the Cubes 729 and 125. And the *Ratio* in this and

(*) Namely the Distance of *Saturn* (as is above observed) from the Sun is 95, and of *Jupiter* 52, both Distances being measured by the same Measure.

the

Of the Copernican

the following Instances would be found more exact, were the Periods and Distances more exactly expressed by Numbers. In like manner the Period of the Earth is a little more than four Times greater than the Period of *Mercury*; and so the Squares of the Numbers expressing those Periods will be almost as 17 and 1. And the Distance of the Earth from the Sun being divided into ten Parts, the Distance of *Mercury* from the Sun is found by Observations to be (little less than 4 such Parts, *viz.*) 3 such whole Parts, and 9 Tenths of another, the Cubes of which Numbers (*viz.* 10 and $3\frac{9}{10}$) are 1000 and 59. But it is obvious, that 17 is to 1, much as 1000 to 59. And so of the other primary Planets.

9.
And also
as to the
secondary
Planets.

As for the secondary Planets, the Periodical Times of the *Satellites* of *Jupiter* are (as is above observed) respectively as $1\frac{3}{4}$, $3\frac{3}{3}$, $7\frac{6}{8}$, and $16\frac{3}{4}$, and their Distances are as $5\frac{2}{3}$, 9, $14\frac{1}{3}$, and 25. But the Square of the Periodical Time of the innermost *Satelles*, namely 3, is to 13 the Square of the Periodical Time of the second *Satelles*, as 170 the Cube of the Distance of the

the innermost from the Center of *Jupiter*, to 736 the Cube of the Distance of the second from the same Center. Likewise 3 is to 51 the Square of the Periodical Time of the third *Satelles*, as 170 to 2890 the Cube of the Distance of the third from the Center of *Jupiter*. And again 3 is to 280 the Square of the Periodical Time of the fourth and outermost *Satelles*, as 170 to 15800 the Cube of the Distance of the said outermost *Satelles* from the Center of *Jupiter*. And the same holds good as to the *Satellites* of *Saturn*. But as to the Moon, it is not applicable to her, forasmuch as she is the only secondary Planet, that moves about the Earth.

From what has been said, evidently appears, that the Periodical Motions of the Planets are performed uniformly, or are regulated by one general Law. And from hence it is demonstrated (†) by the Learned, that the Planets are likewise retained in their

10.
All the
Planets
retained in
their own
Orbits by
Gravity.

(†) See Dr. Gregory (late Savilian Professor at Oxford,) his *Astron. Phys. and Geom. Elem. lib. 1. prop. 27, 28, 29. and Sect. 6. and 7.* I shall only observe here,

their proper *Orbits* after an uniform Manner, by one Sort of Force which makes them tend to the Center of their respective *Orbits*, and is thence called *the Centripetal Force*, or in one Word *Gravity*. And this is another Particular, wherein appears the Excellency of the *Copernican* System above any other; forasmuch as this System may be preserved by Gravity alone, uniformly propagated through the Universe, whereas (||) all the other Systems require some (one or more) other Force, besides that of Gravity.

II.
All the
Planets re-
ceive their
Light from
the Sun.

All the Planets, Primary and Secondary, are Opacous Bodies, *i. e.* such as have no Light of their own, but receive all their Light from the Sun; and so for this, as well as other Reasons, are accounted as so many Dependants of the Sun. Whence the

here, that any Body, when moved, will move uniformly in a straight Line, if not hindered. And agreeably any Planet would fly out of its *Orbit* into a right Line, which is a Tangent to its *Orbit*, was it not hindered or pulled back and retained in its *Orbit* by some Centripetal Force, *i. e.* by Gravity.

(||) See *Greg. Astron. Phys. and Geom. Elem.* pag. 111, 112.

Sun

System in general.

15

Sun with these its Dependants make up what is called the *Solar System*, described, *Fig. 1.*

As for the other Celestial Lights, ^{12.} called the *Fixed Stars*, they are inde- ^{Of the Fixed Stars.}pendent of the Sun, as in other Respects, so in respect of Light; forasmuch as they receive not their Light from the Sun, but shine with their own Native Light. Hence they are esteemed to be, not only without this our Solar System, but as so many Suns themselves, each being placed in the Center of some such System, as this our Solar System, and there so *fixed*, as to have no Motion, but round their own *Axis*. They are supposed to be vastly distant from this our Solar System; which is the Reason that their Distance is taken no Notice of in the Description of the *Copernican System*, *Fig. 1.*

Besides the Celestial Lights already ^{13.} mentioned, there appear sometimes ^{Of Comets.} *Comets*; which is originally a *Greek* Word, denoting in that Language as much as *Hairy*. These Lights are called by the *Greeks*, *Hairy Stars*, because they fancied the Streams of Light, which attend such Stars, to resemble

resemble Hair. It is found by Observations, that these Comets do (*) pass through the Planetary Orbs of this our Solar System ; but whether they depend only on the Sun, and so belong only to this our Solar System, or whether they move in Circular or such like Lines, or whether they are so much as durable Bodies, is not yet discovered. For which Reasons, there is no Notice taken of them, *Fig. 1.*

14. Before we conclude this Chapter concerning the *Copernican* System in general, it seems proper to observe, that although the *Orbits* wherein the Planets move, are described, *Fig. 1.* as so many Circles, and may be well enough conceived as such in many Respects ; yet more strictly speaking, they are not exactly Circular, but Elliptical.

15. Further it seems not improper to observe also here, that the fixed Stars being the most remote of all the Celestial Lights, and appearing to us as placed in one Concave Sphere ; hence it is usual to denote the *Place* of any

(*) Hence the Line Comet describes by its Motion, is called its *Trajectory*.

of the intermediate Celestial Lights, by assigning what Part of the Sphere of the fixed Stars they appear to us to be *in*, or more properly *under*. And accordingly it is usual to distinguish that Tract of the Sphere of the fixed Stars, under which all the Planets do move, by the Asterisms or Constellations that lie in that Tract; which being fancied to represent several Things, are therefore called *Signs*; and because the Things represented by them are most of them (†) *Zodia*, or Animals, hence all this Tract is stiled the *Zodiack*. Now the *Orbit*, wherein the Earth performs its Annual Period (and which the Sun seems to move round every Year) runs under the very Middle of the *Zodiack*; whence this middle Part of the *Zodiack* is of special Note in *Astronomy*, and is therefore distinguished by a peculiar Name, being called the (||) *Ecliptick*. It, as well as the whole *Zodiack*, is divided into twelve

(†) It is a Greek Word signifying *Animals* or *Living Creatures*.

(||) The Reason of this Name. See *Chap. 5. Sect. 21.*

Of the Copernican

Parts, distinguished by the Name of the Constellation or Sign, to which each Part was formerly assigned. The (*) Names of the said Signs, together with the Characters whereby they are denoted in short, are as follows, *viz.*

♈	♉	♊	♋	♌	♍
<i>Aries,</i>	<i>Taurus,</i>	<i>Gemini,</i>	<i>Cancer,</i>	<i>Leo,</i>	<i>Virgo,</i>
♎	♏	♐	♑	♒	♓
<i>Libra,</i>	<i>Scorpio,</i>	<i>Sagittarius,</i>	<i>Capricornus,</i>	<i>Aquarius,</i>	<i>Pisces.</i>

16.
Of the
Nodes of
the Pla-
nets.

Lastly, It seems proper here to observe, that the Planets do not move in *Orbits*, which exactly run one over the other, or are all contained in the same Plane; but their *Orbits* do all cross one another according to several Degrees of Inclination, or which is the same, the Planes of their *Orbits* are variously inclined one to the other. Now the Earth being that Planetary Body we live on, hence the Plane of the *Orbit* of the Earth is taken by Astronomers for the Standard; and the Inclination of the Planes of the

(*) The Names of the Signs are somewhat differently expressed in these two memorial Verses, *viz.*

Signa, Aries, Taurus, Gemini, Cancer, Leo, Virgo,
Libraq; Scorpius, Arcitenens, Caper, Amphora, Pisces.
Orbits

System in general.

19

Orbits of the other Planets is reckon-
ed greater or less, as the said Planes
incline more or less in respect to the
Plane of the Earth's *Orbit*, or (†)
(which comes to the same) to the
Plane of the *Ecliptick*. The two
Points, wherein the *Orbit* of any Pla-
net crosses the *Ecliptick*, are called the
Nodes of that Planet. And thus much
for the System of the World in gene-
ral, and such Particulars as relate to
it in general.

(†) For the *Ecliptick* is that Part of the Sphere of
the fixed Stars, which the Plane of the Earth's *Orbit*
produced thereto touches. So that the *Ecliptick* is
no other than the Extremity of the Plane of the Earth's
Orbit.

C H A P. II.

Of the Diurnal Phænomena common to the Celestial Lights.

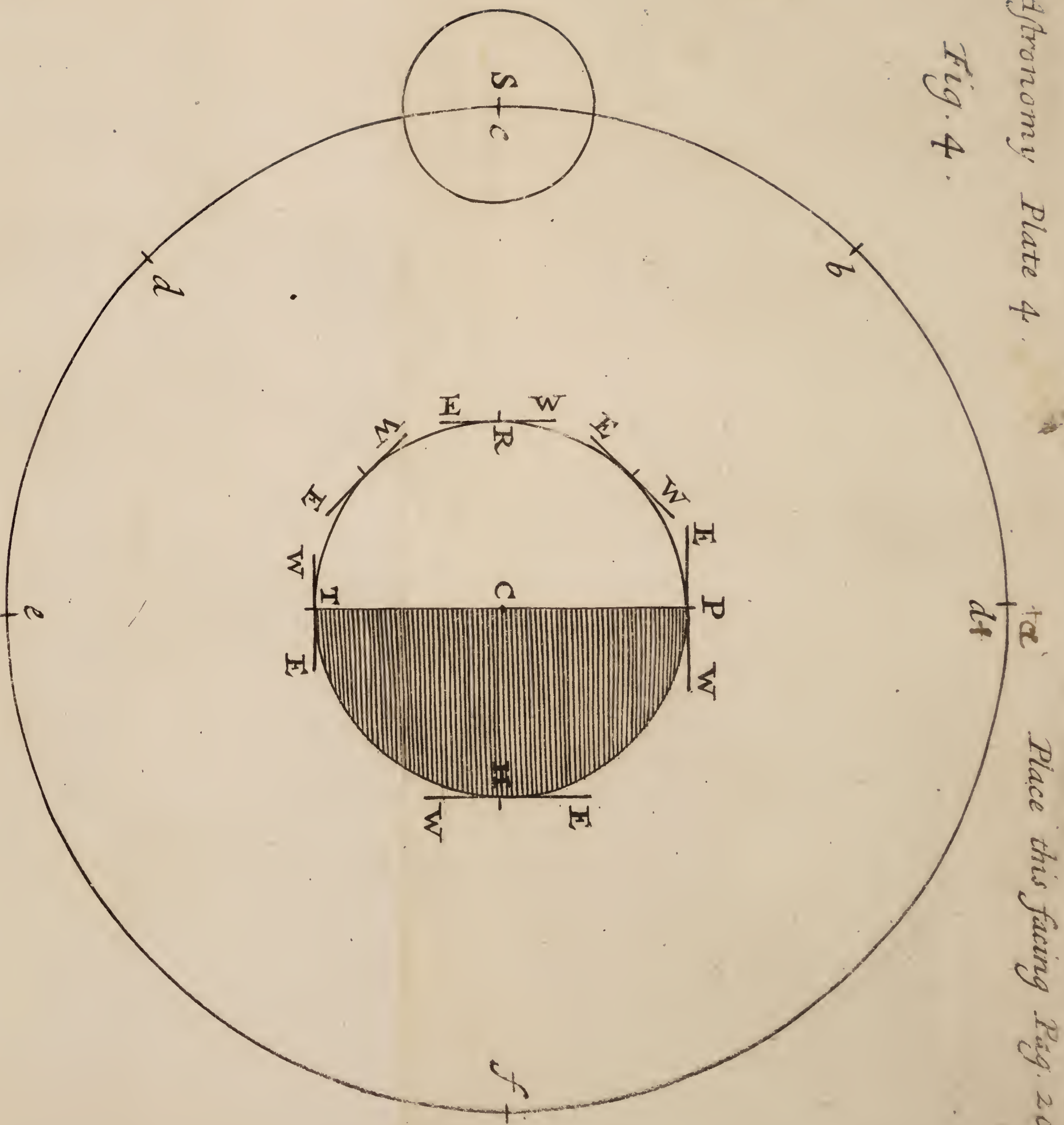
I.
The Diurnal
Phænomena
are common
to the
Celestial
Lights in
general

HAVING in the foregoing Chapter explained, so far forth as is sufficient to the Design of this Treatise, the *Copernican* System in general, I now proceed to explain agreeably thereunto the *Phænomena* of the Celestial Lights. I shall begin with explaining the *Diurnal Phænomena* common to them in general, *viz.* their Rising, Setting, &c.

2.
They are
to be solved
by the
Diurnal
Revolution
of the
Earth.

Now these *Diurnal Phænomena* of the Celestial Lights may be solved by the *Diurnal Revolution* of the Earth, *i. e.* by one single Revolution of the Earth round its own *Axis* in 24 Hours. This is illustrated *Fig. 4*, where the Circle *P R T H* denotes the Earth; *C* the Center of the Earth, thro' which it is to be conceiv'd to pass perpendicularly its *Axis*, round which it makes its *Diurnal Revolution*. *P* denotes any Place on the Earth; the Line *EW*,
that

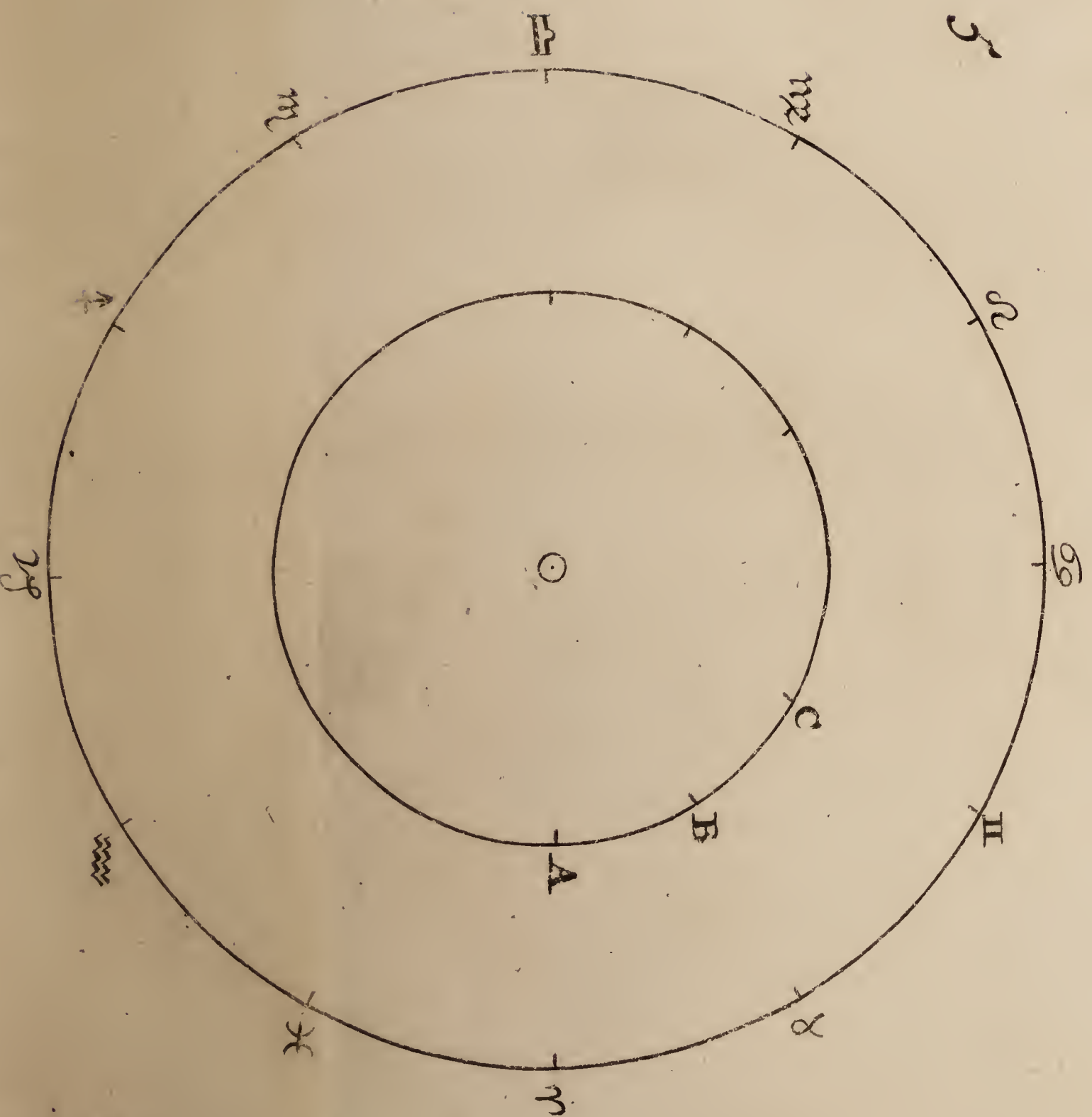
Fig. 4.



Place this facing Fig. 20.

Fig. 26.

Fig. 5.



that Circle which bounds the Sight in the said Place, and is by *Astronomers* called the (*) *Horizon*; E the East Point of the said *Horizon*, W the West: the Circle *abcdef* denotes the Circumference of the Heavens; the Circle S the Sun in the Heavens; the Semicircle P R T, the enlightened Hemisphere of the Earth, or that Half of it which is opposite to the Sun; the Semicircle P H T, the darkened Hemisphere of the Earth. Now the Earth being supposed in this Situation, and also to move round its *Axis* towards the Sun; it is evident, that the Place P of the Earth will just begin to be enlightened by the Sun, and so the Sun will appear there to be just Rising, or ascending the *Horizon* at E the East Point of it. The Earth being moved round its own *Axis*, so as that the Place P of the Earth, which afore was under the Point *a* in the Heavens, now is under the Point *b*; it is evident, that the *Horizon* of the said Place P, will be now so situated, as that the Sun will appear to a Spe-

(*) It is a *Greek* Word, denoting in that Tongue somewhat that *bounds*.

Of the Diurnal Phænomena

Etator at P, as ascended considerably above E the East End of the *Horizon*. And while, by the Revolution of the Earth round its *Axis*, the Place P passes from under the Point *b* in the Heavens to the Point *c*, the *Horizon* of the Place P will continually sink lower and lower in Respect of the Sun, and so the Sun will appear to ascend higher and higher, till P is come under *c*, where the Sun will appear in its greatest Height above the *Horizon* for that Day; and so it will be Noon or Mid-Day; at the Place P. For the Earth moving on, as the Place P passes from under *c* to *d*, the West Point of its *Horizon* will ascend higher and higher, and so the Sun will appear more and more to descend, as is represented by the *Hori-*
on at the Point of the Earth under *d*. The Place P being carried by the *Diurnal Revolution* of the Earth from under *d* to under *e*, the Sun will then appear just on W the West Point of the *Horizon*, and so will appear to be just Setting. The Place P being come under *f*, it will be then Mid-night there. *Lastly*, the Place P being come round again under *a*, it will be there
Sun-

Sun-rising again. And thus it has been shewn, that the same *Diurnal Phenomena* of the Sun will come to pass, if the Sun stands still, and the Earth move round its own *Axis* from West to East, or from under *a*, to under *b*, *c*, *d*, &c. in the Heavens; as are commonly esteemed to come to pass by the Earth's standing still, and the Sun's moving round it from East to West, or from *c* to *b*, *a*, *f*, &c. And that the same holds good as to any other Celestial Light, and the Earth, is obvious to shew from *Fig. 4*, the Circle representing the Sun being taken to denote any other Celestial Light.

But now it being justly received 3.
by Philosophers as an unquestionable Truth, that *Nature works after the most simple and compendious Manner*; it thence follows, that the Solution of the *Diurnal Phenomena* by the Revolution of the *Earth* alone round its own *Axis*, is much more agreeable to Nature, than the Solution of the said *Phænomena* by the Revolution of *all the several Celestial Lights* round the Earth.

The Probability of the Copernican System further established.

24 *Of the Diurnal Phænomena, &c.*

4. *The common and proper Motion of the Celestial Lights, what.* It remains only to observe, that whereas by the *Diurnal Revolution* of the Earth, all the several Celestial Lights seem to move in the Heavens from East to West, hence this seeming *Diurnal Motion* of the Celestial Lights is called their (†) *common Motion*, as being common to all of them. Besides which all the Celestial Lights, but the Sun, have a *proper Motion*; from which arise their *proper Phænomena*. As for the *proper Phænomena* of the Sun, they likewise seem to arise from the *proper Motion* of the Sun, but are really produced by another Motion which the Earth has, and whereby it moves round the Sun once every Year, whence it is called the *Annual Motion*

(†) The *Diurnal Motion* is also called *Motus Primus*, either because it is usually first treated of, or else because it is supposed according to the *Vulgar* or *Ptolemaick System* to be caused by the *Primum Mobile*, which according to the said System is a Sphere above the fixed Stars, carrying all the Celestial Lights along with it from East to West. Whence the said *Diurnal Motion* is also called sometimes *Motus Raptus*. In like manner the *proper Motion* is otherwise stiled *Motus Secundus*, in Contradistinction to the *Diurnal Motion* called *Motus Primus*.

of

of the Earth. Having therefore explained in this Chapter the *Diurnal* and common *Phænomena* of the Celestial Lights, I proceed to explain their proper *Phænomena*.



C H A P. III.

Of the Phænomena (commonly ascribed to the seeming Annual Motion of the Sun, but rather) depending on the real Annual Motion of the Earth.

I. *The proper Phænomena of the Sun, why first explained.* **B**Eing to explain in the next Place the *Phænomena proper* to the several Celestial Lights, I begin with the proper *Phænomena* of the *Sun*; forasmuch as the *Sun* is the principal Light of that System of the World, wherein we are placed.

2. *The seeming Proper or Annual Motion of the Sun is caused by the real Annual Motion of the Earth.* Now these *Phænomena* of the *Sun*, which are vulgarly ascribed to the seeming *Annual Motion* of the *Sun*, may be solved by the *Annual Motion* of the *Earth*. In order whereunto it is first to be shewn, that the *Annual Motion* of the *Earth* will cause the *Sun* to appear to us, as if it had such an *Annual Motion*, though it really has no such Motion. And this is illustrated *Fig. 5*, where the *Sun* is in the

Of the Annual Phænomena, &c. 27

the Center; the Circle next round it denotes the *Orbit* of the Earth, or that Circular Line which the Center of the Earth describes by its Annual Motion; the outermost Circle denotes the *Ecliptick*, distinguished into its 12 Parts or Signs. Now supposing the Earth to be at A, the *Sun* will appear to us to be at $\sphericalangle$; and supposing the Earth to move from A to B, and so to C, the *Sun* will thereby appear to us to move from $\sphericalangle$ to m , and thence to $\dagger$. And in like manner, by the Earth's Motion along the Rest of its own *Orbit* till it comes to A again, the *Sun* will seem to us to move along the Rest of the *Ecliptick* till it comes to $\sphericalangle$ again. 'Tis evident then, that, supposing the Earth to move as has been here described, the *Sun*, though it really stands still, will seem to have the same *Annual* Motion along the *Ecliptick*, as it would have, if it really moved so, and the Earth stood still.

Only 'tis remarkable, that whereas we commonly say, *the Sun is in $\sphericalangle$ or Libra*, when it is between us and *Libra*, (and so of any other Sign,) if we would speak properly, and agreeably to the natural

3
An Observation as to the common Way of saying, that the

Sun is in
such or
such a
Sign.

natural Cause of this (and such like) *Phænomenon*, we should say, that *the Earth is then in* γ or *Aries*; forasmuch as the Earth in its real Motion is always in the Point of the *Ecliptick* opposite to that, wherein the *Sun* appears to be.

4
The Variety of the Seasons, &c. how to be solved by the Annual Motion of the Earth.

Having shewn that the *Annual Motion* of the *Earth* along the *Ecliptick* will make the *Sun* appear to us, as if it had such an *Annual Motion*; I proceed now to shew, how the Variety of Days and Nights as to their Length, and the various Seasons of the Year, (all commonly ascribed to the seeming *Annual Motion* of the *Sun*;) may be solved by the *Annual Motion* of the *Earth*. And this is illustrated *Fig. 6*; for the clearer Understanding whereof there are to be premised the following Particulars.

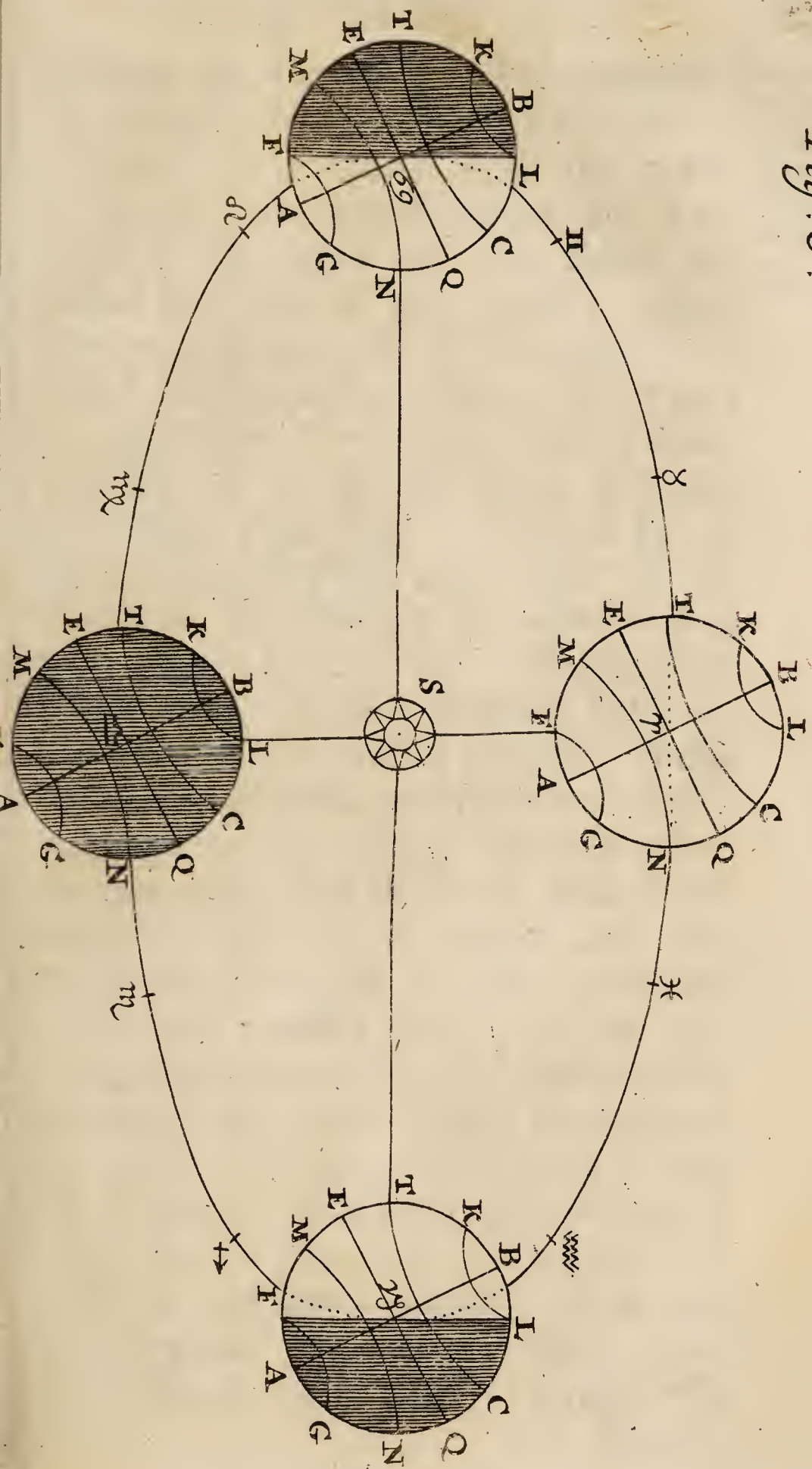
5
Of the Equator, its Axis and Poles; as also of the Tropicks.

As the (*) *Axis* of the Earth (and so of the *Sun*, or any other Celestial Body) is the very Mid-line of it, which consequently passes through its Center, and is represented, *Fig. 6*,

(*) The right Line, round which Bodies or Circles are conceived to move, are so called in Allusion to the *Axis* or Axle-tree of a Chariot or Cart-wheel.

(where

Astronomy Plate 5.
Fig. 6.



Place this facing Pag. 28.

(where the Circle A Q B E represents the Earth,) by the right Line A B ; so the two Ends of any *Axis* are called its *Poles*, and consequently the two Ends of the *Axis* of the Earth are called the *Poles* of the Earth ; which always pointing one Northwards, the other Southwards, hence the former is called the *North Pole*, and is denoted, *Fig. 6*, by B ; the latter is called the *South Pole*, and is denoted by A. Between these Poles each Point of the Earth by its *Diurnal Revolution* does describe a Circle ; of which that, which is in the very Middle between the Poles, and is the greatest, is called the *Equinoctial* or *Equator*, (denoted *Fig. 6*. by EQ,) because when the *Sun* is in the Plane of this *Equinoctial* Circle, it is equal Day and Night all over the World. And did this Circle exactly answer to, or run along under the *Ecliptick*, there would be equal Day and Night throughout the Year all over the World. But the Equator crossing the *Ecliptick*, hence it is equal Day and Night only twice in the Year, namely, when the *Sun* appears in one of those two Points of the *Ecliptick*, where the

Polar Circles Equinoctial Points, Solstitial Points, &c.

Equator

Equator crosses it, viz. in the first Degree of *Aries*, and the first of *Libra*; which are therefore called the two *Equinoctial Points*; and the Times of the Year answering thereto, the two *Equinox's*, one the *Vernal*, the other the *Autumnal*. Among the other Circles, which the several Points of the Earth by its *Diurnal Revolution* describe between the two Poles of the Earth, and which are all parallel to the *Equator*, there are four more remarkable, the two *Tropicks*, and the two *Polar Circles*. The two *Tropicks* are those Circles on the Earth, which the *Sun* seems to go directly over, when it is at its greatest *Declination* or Distance from the *Equator*, either Northward or Southward. Whence one is called the *Northern Tropick*, the other the *Southern*. And because when the *Sun* appears to move vertically over the Northern *Tropick*, he appears also to be in the Beginning of *Cancer*, hence the said *Tropick* is frequently stiled the *Tropick of Cancer*; and for the like Reason the Southern is otherwise stiled the *Tropick of Capricorn*. The Reason why both these Circles are called *Tropicks*,

picks, is because the Sun appearing then at his greatest respective (Northern or Southern) Declination or Distance from the Equator, begins from thence presently to (†) turn back again towards the Equator, And because the Sun in the first Degree of Cancer and Capricorn does as it were make a Stand, going neither Northward nor Southward further from the Equator, hence these two Points of the Ecliptick are called the two Solstitial Points; and these two Times of the Year are called the two Solstices, one the Summer, the other the Winter. The Tropick of Cancer is represented, Fig. 6. by the circular Line T C, the Tropick of Capricorn by M N. The two Polar Circles are so called, either as being near to the two Poles of the Equator, or because they on the Earth (||) answer to those Circles in the Heavens,

(*) The Greek Verb *τρέπω* signifies to turn; whence is derived *τροπή* denoting somewhat from whence a Turn is made.

(||) As every Point of the Earth by its real Diurnal Revolution, does really describe a Circle between the two Poles of the Earth; so the Sun, by its seeming Diurnal Revolution, does seemingly describe every Day

Of the Annual Phænonema

Heavens, which the (*) *Poles* of the *Ecliptick* seem to describe by the apparent *Diurnal* Motion of the Heavens. Hence these *Polar* Circles are just as far distant from their respective *Poles* of the *Equinoctial*, as are the *Tropicks* from the *Equinoctial*, viz. $23\frac{1}{2}$ Degrees, this being the Measure of the Angle, which the Planes of the *Equator* and *Ecliptick* make by their mutual Inclination. These *Polar* Circles do bound those Tracts of the Earth, where it is Day or Night during more or fewer whole *Diurnal* *Revolutions* of the Earth, or for 24

Day a Circle, directly answering in the Heavens to that Circle on the Earth, to which the *Sun* is that Day Vertical. Hence there are usually conceived in the Heavens, *Equinoctial* and *Tropical* Circles, which directly answer to the like *Terrestrial* Circles.

(*) As the Earth, Sun, and all the other Celestial Bodies are said to have their respective *Axes*; so the Astronomical Circles (viz. *Ecliptick*, *Horizon*, &c.) are conceived by Astronomers to have their respective *Axes*; each of which is conceived to be a right Line passing through the Center of the said Circles, so as to be perpendicular to their respective Planes: And the Extremities of any such *Axis* is likewise called the *Pole* of the Circle, to which the said *Axis* belongs. And consequently (the *Axis* being always perpendicular to the Plane) the *Poles* of any Circle are always distant, each 90 Degrees from the said Circle.

Hours

Hours and upwards together. Of these *Polar* Circles, one is termed the (†) *Arctick* or northern *Polar Circle*, as being nigh the *Arctick* or north Pole of the *Equator*, and the other for the like Reason is termed the *Antarctick* or southern *Polar Circle*. The former is denoted *Fig. 6*, by the circular Line *K L*, the latter by *F G*. It only remains to observe, that the *Sun* (or any other *Celestial Light*) will appear to be vertical to that Point of the Earth, where a right Line drawn from the Center of the *Sun* (or other *Celestial Light*) to the Center of the Earth, crosses the Surface of the Earth. Thus *Fig. 6*, when the Earth is in the Beginning of *Capricorn* or at *w*, the *Sun* will appear to be vertical to the northern *Terrestrial Tropick* or *T C*, because a right Line drawn from *S* to *w*, will cross the Surface of the Earth at *T*. So when the Earth is at *v*, the *Sun* will appear vertical

(†) The north *Pole* of the *Equator* is called otherwise the *Arctick*, because it is near the Constellations called the great and little Bears; the *Greek Word* *Αρκτῶν signifying a Bear; and hence the southern *Pole* is stiled the *Antarctick*, as being opposite to the *Arctick*.

Of the Annual Phænomena

to the Terrestrial *Equator* or *E Q*, because a right Line drawn from *S* to *r* will cross the Surface of the Earth in a Point of *E Q*; for in this Position of the Earth the Line *S r* is to be conceived perpendicular to the *Axis A B*. These Particulars being premised and apprehended, it will be easy to apprehend how the various Length of Day and Night, and the various Seasons of the Year are produced by the *Annual Motion* of the Earth.

6. Suppose then the Earth to be at ∞ , the *Sun* (as is afore observed, *Sect.* 3.) will appear at *r*, and so in one of the *Equinoctial* Points, and in the Middle between the Poles of the Earth *A* and *B*; and consequently will enlighten from Pole to Pole, that Hemisphere of the Earth which is opposite to it. Whence Half of the Terrestrial *Equator E Q*, and of every Circle parallel thereunto, will at that Time be enlightened by the *Sun*, and Half will be in the Dark. And consequently every Place on the Earth (forasmuch as it lies either in the Terrestrial *Equator*, or some Parallel to it) being carried round the *Axis*,

The Ver-
nal Equi-
nox ex-
plained by
the Annual
Motion of
the Earth.

Axis, of the Earth in an uniform Manner by the *Diurnal* Motion of the Earth, will be as long in the Light, as in the Dark, *i. e.* the Day and Night will be then *equal* all over the Earth.

The Earth being moved by its *An-* 7.
nual Motion from $\simeq$ to ϖ , the *Sun* The Reason of the Days being longest at the Summer Solstice.
 appears then to us to be in $\odot$, where is its greatest Declination northward. And the *Sun* being in this Situation, 'tis evident, that the Rays of the *Sun*, which enlighten one Half of the Globe of the Earth at a Time, reach beyond the north Pole B to L, and at the south Pole reach no further than F. Whence it follows, that the Tract of the Earth within the north *Polar Circle* K L, at this Time of the Year enjoys Day-light throughout the whole *Diurnal Revolution* of the Earth; and on the contrary, that it is continual Night throughout the whole *Diurnal Revolution* of the Earth, in the Tract of the Earth lying within the south *Polar Circle* F G. It follows also, that the greater Portions of the Parallels to the *Equator*, which lie between the *Equator* and northern *Polar Circle*, have the Light of the
 D 2 Sun;

Sun; but the greater Portions of such Parallels, as lie between the *Equator* and southern *Polar Circle*, have not the Light of the *Sun*; and the Portion of the Parallel, which is or is not enlightened, is so much the greater or lesser, as the Parallel is more or less distant from the *Equator*, there being exactly one Half of the *Equator* always enlightened, and the other not. And hence it is, that in this Position of the Earth in the first of *Capricorn*, when the *Sun* seems to be in the opposite, *viz.* first Degree of *Cancer*, the Days are longest in the northern Parts of the Earth, and the Nights shortest, and so it is Summer there. Whereas in the southern Parts of the Earth, the Days are then shortest, and the Nights longest, and so it is there Winter. And the longest Day is so much the longer, as the Place is more remote from the *Equator*. But to such as live on the Terrestrial *Equator* it self, Day and Night are now, and throughout the whole Year, equal one to the other, for the Reason above-mentioned.

The

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Astronomy Plate 6.

Fig. 7.

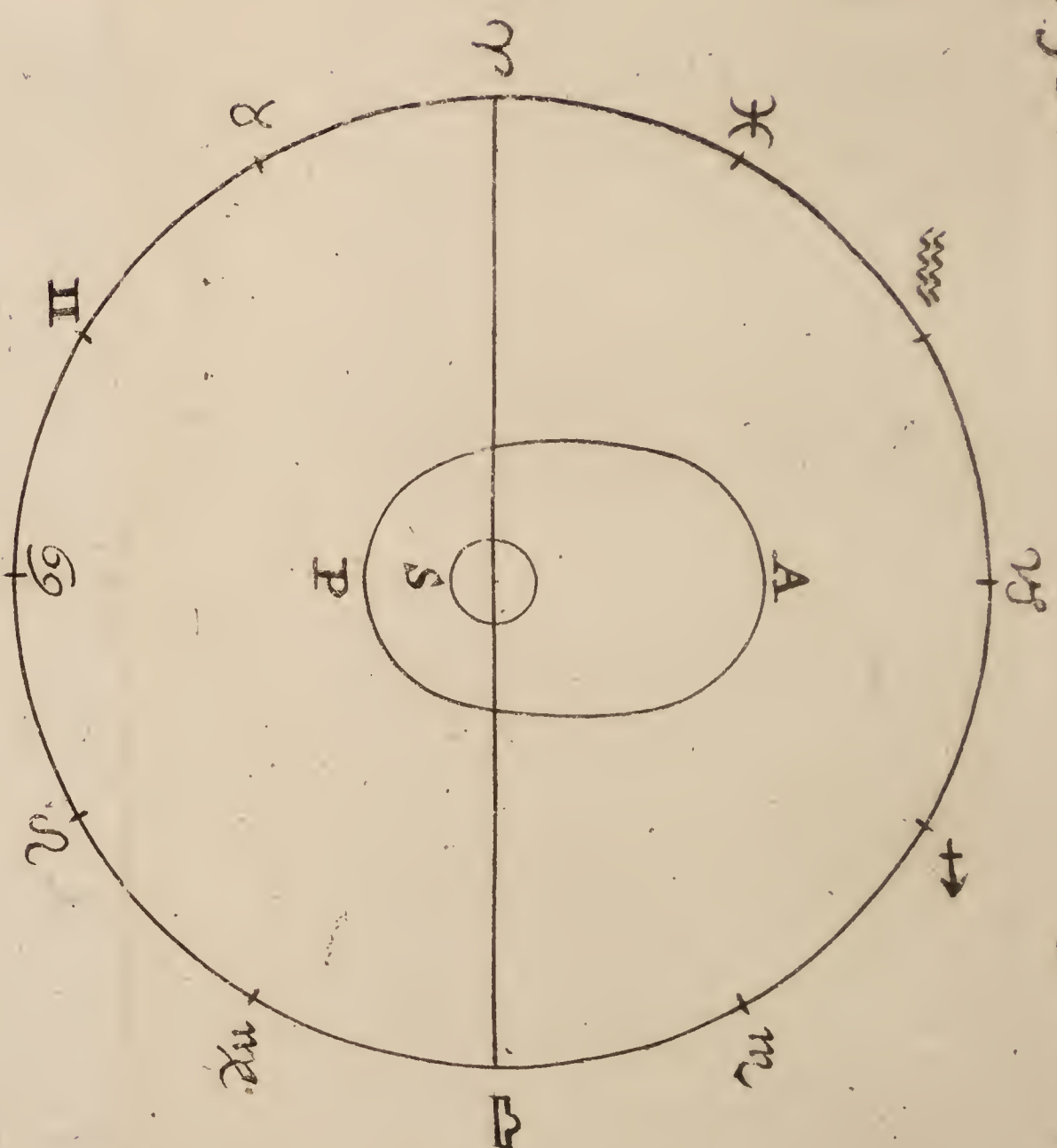
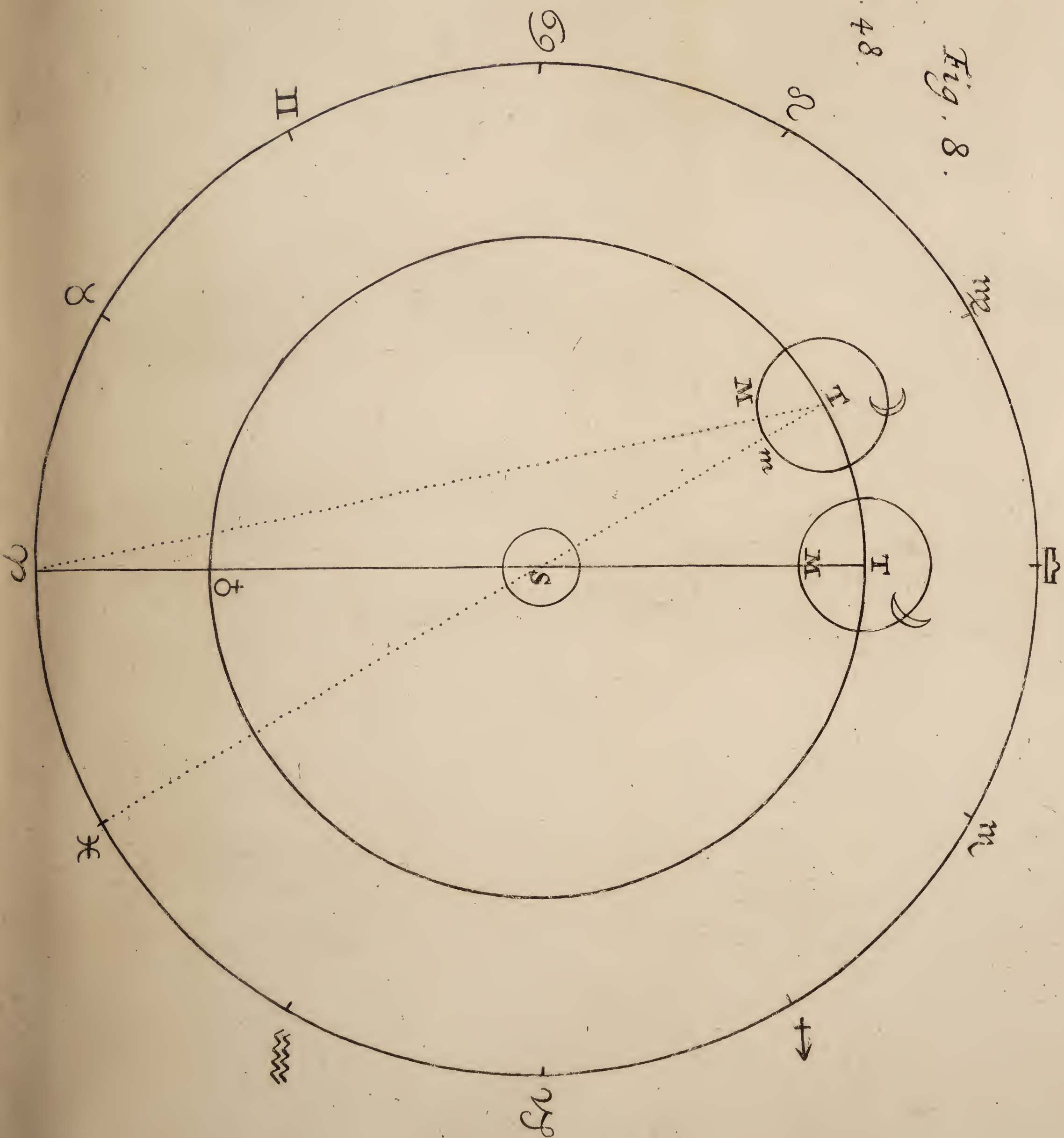


Fig. 8.

Page 48.



The Earth moving from ϖ to γ ,
the *Sun* will seem to move from $\odot$ to $\sphericalangle$, and so will appear in the Celestial Equator, and make Day and Night equal, as when the Earth was at the opposite Point $\sphericalangle$, for the like Reasons. In like manner the Earth moving from γ to $\odot$, the *Sun* will seem to move from $\sphericalangle$ to ϖ , where it is in its greatest southern Declination. And consequently at this Time of the Year, the like *Phænomena* will happen to the Inhabitants of the southern Hemisphere of the Earth, as happened to those of the northern Hemisphere, when the Earth was in ϖ ; and the like *Phænomena* will be in the northern Hemisphere, as were afore in the Southern.

8.
The Autumnal Equinox, and the Reason of the Days being shortest at the Winter Solstice, explained.

Having thus shewn, that the same
Phænomena, as to the Length of Day and Night, and so as to the various Seasons of the Year, will arise from the *Annual* Motion of the *Earth* round the *Ecliptick*, as from that of the *Sun*, at the four Cardinal Points of the *Ecliptick*, viz. the two *Equinoctial*, and the two *Solstitial* Points; it is obvious, that the same *Phænomena* will likewise happen at any the intermedi-

9.
The Solution of the like respective Phænomena at the intermediate Points of the Ecliptick, is easily to be inferred from what has been said.

ate Points of the *Ecliptick*, from the Motion of the one as well as of the other, as to the Increase and Decrease of Day and Night, and consequently as to the Difference of Seasons.

10.

Of the different Distance of the Sun from the Earth, its seeming different Magnitude, and different Rate of Motion.

As the *different Length* of Day and Night, and the different Seasons at different Times of the Year are *Phænomena*, which escape no one's Observation, and have been already accounted for; so there are other *Phænomena* of the *Sun*, which are not so easily to be observed, and therefore are taken Notice of only by the more curious in these Matters. Such is the *different Distance* of the *Sun* from the Earth at different Parts of the Year; as also its appearing of a *different Magnitude*, and its seeming to move at a *different Rate*. For as the *Sun's* Diameter appears lesser about the Middle of *June*, and greater about the Middle of *December*, so the *Sun* is more distant from us in our Summer, than in our Winter; and also seems to move slower in the former, than in the latter; insomuch that it takes up about eight Days more in its seeming to pass from the Vernal to the *Autumnal Equinox*, than in its seem-

ing

ing to pass from the *Autumnal* to the Vernal; although in both Intervals of Time it seems to pass over but an equal Portion of the *Ecliptick*, namely, just Half. These *Phænomena* of the *Sun*, as they depend one on the other, so may be all solved by the *Annual* Motion of the Earth, in an *Elliptical Orbit*, round the *Sun* placed in one of the (||) Focus's of the Ellipsis, as is illustrated, *Fig. 7*, where the Circle represents the *Ecliptick*, the Ellipsis represents the *Orbit* of the Earth, S the *Sun* placed in one of the Focus's of the said Ellipsis. Now about the Middle of *June* the *Sun* appears to us in the Beginning of *Cancer*, and consequently the Earth is in the Beginning of *Capricorn*, and so at the Point A of its *Elliptical Orbit*, that is, at its (*) *Aphelium* or greatest Distance from the *Sun*; whence the
Sun

(||) In *Fig. 6*. the *Sun* is placed in the Center, not one of the Focus's, only for more Conveniency sake in drawing the Figure. It may be easily conceived to be in the Focus next to the Sign of ♋, where it ought to be strictly:

(*) What is here called the *Aphelium* and *Perihelium*, is by such, as follow the Hypothesis of the *Sun's*

Of the Annual Phænomena

Sun appears then less to us. About the Middle of *December*, the *Sun* appears to us in the Beginning of *Capricorn*, and consequently the Earth is then in the Beginning of *Cancer*, that is, at the point P of its *Elliptical Orbit*, and so at its *Perihelium*, or least Distance from the *Sun*; which therefore appears to us then greater. Further, as the Line drawn from γ to α through the Center of the *Sun* S, divides the *Ecliptick* into two Halves, so it unequally divides the *Orbit* of the Earth; the greater Segment whereof answers to the six Signs of the *Ecliptick*, which the Earth passes under between the Vernal and Autumnal *Equinox*; and the lesser Segment answers to the other six Signs of the

real Annual Motion, called the *Apogee* and *Perigee*; and these suppose the *Sun* to move *Annually* round the Earth in an *Eccentric Circle*, which comes much to the same as an *Elliptical Orbit*. The *Apelium* and *Perihelium* are not always in the same Points of the *Ecliptick*, but move a little and a little forwards according to the Series of the Signs. The former is at present reckoned about the 7th Degree of *Capricorn*, and the latter about the 7th Degree of *Cancer*. They are both Words derived from the Greek Language, and therein of the Importance above specified.

Ecliptick,

Ecliptick, which the Earth passes under between the Autumnal and Vernal *Equinox*. Whence it comes to pass, that the Earth taking up more Time to go along the greater Segment of its Orb, than the lesser, the *Sun* seems to take up more Time, and consequently to move more slowly, in passing along the six Signs of the *Ecliptick*, which it seems to pass thro' between the Vernal and Autumnal *Equinox*, than it does in passing along the other six Signs of the *Ecliptick*, which it seems to pass thro' between the Autumnal and Vernal *Equinox*.

As the Time of the Earth's *Annual* Motion from any Point of the *Ecliptick* to the same again, is computed 365 Days, 5 Hours, and 49 Minutes; so the Time of the Earth's Motion from the Vernal to the Autumnal *Equinox*, is computed 186 Days, besides some odd Hours and Minutes; and from the Autumnal *Equinox* to the Vernal, 178 Days, besides some odd Hours and Minutes. So that the Difference between these two Intervals of Time is (as afore has been observed) about eight Days.

II.

The Time
of the
Earth's
Annual
Motion, or
of the So-
lar Year.

But

I 2.

*The Sun,
why hotter
to us in
Summer,
though
farther
from us.*

But there are two Difficulties, which are to be removed. One is in reference to what has been said concerning the *Sun's* being more distant from the Earth in Summer than in Winter. For since the *Sun* is the Fountain of Heat as well as Light to the Earth, it may be asked, how it comes to pass, that the *Sun* is *hotter* to us in Summer than in Winter; if so be it be *farther* from us in the former than in the latter. Now this Difficulty will be removed by considering, that the *Sun* (or any other Body of Fire) feels more or less hot to us, not only as it is nearer or further from us, but also as its Rays come more or less directly to us. Whence though the *Sun* be farther from us in Summer than in Winter, yet because its Rays are much more nearly perpendicular to us in the former than in the latter, therefore it is hotter to us in the former than in the latter Season. That the Rays of the *Sun* fall more nearly perpendicular, or more directly upon us in the Summer than in Winter, is obvious to infer from *Fig. 6*. For when in Summer the Earth is in the Beginning of ϖ , and consequently the

Sun

Sun appears to be in the Beginning of ☊, the *Sun* is then in a perpendicular Line to T, or the Rays of the *Sun* then fall perpendicularly on the Terrestrial Tropick T C; and therefore, although the Earth be about that Time in its *Aphelium* or greatest Distance from the *Sun*, yet the *Sun* is then hottest to us in these Parts of the Earth north of the said Tropick. But as the Earth moves from the Beginning of ♈ towards ♊ and ☊, so the Perpendicular from the *Sun* to the Earth moves from T towards M N the Southern Tropick, so that the *Sun* is exactly perpendicular to N M when the Earth is in the first of ☊, or at the Winter Solstice. Wherefore, although the Earth be about that Time in its *Perihelium* or least Distance from the *Sun*, yet the *Sun* is not then so hot to us, because its Rays fall more obliquely; as is evident by supposing a right Line drawn from the *Sun* to the point T in that Position of the Earth at ☊.

The other Difficulty is in reference 31.
to the *Annual* Motion of the Earth ^{The}
round its Orbit. For such a Motion ^{Change of}
seems inconsistent with the Earth's ^{the Earth's} Place in
retaining ^{its Annual}

Orbit, *why* retaining always the same Situation in
it makes Respect to the fixed Stars. But it is
no sensible Change as to be known, that the Circle of the
 to the Earth's *Situation* in Respect of the Sphere of the fixed Stars,
 Earth's Si- that the Earth's changing its Place in
 tuation in the said Orbit by its *Annual* Motion,
 respect of the fixed Stars. makes no sensible Change of the
 Stars. Earth's Situation in Respect of the
 fixed Stars. In whatever Point of her
Annual Orbit the Earth is, its *Axis*
 and *Equator* (being each every where
 Parallel to it self) will, if produced,
 fall on the same fixed Stars as to our
 Sense, or so far forth as we can dis-
 cern by our Sight; and consequently
 all the Rest of the fixed Stars (foras-
 much as they retain the same Situa-
 tion among themselves) will (†) re-
 tain the same Situation in Respect of
 the Celestial *Equator* and *Poles*; the
 Celestial *Equator* being always directly
 over the *Terrestrial*, and the Celestial
Poles being always directly in a
 right Line with the *Poles* of the
 Earth.

(†) Excepting the Change mentioned, Chap. 7.
 Sect. 5.

These Difficulties being removed, 14.
the only *Phænomenon* which remains An Eclipse of the Sun, improperly so called.
here to be taken Notice of, is that
commonly called *the Eclipse of the Sun*, but which ought to be called *the Eclipse of the Earth*. For the Word *Eclipse* does in the *Greek Tongue* signify a *Deficiency*; and it is used in this Case to signify particularly that *Deficiency of Light*, which seems indeed to us to be in the *Sun*, but in reality is such only in Respect of the *Earth*. For the *Sun* is the Fountain of Light to this our Solar System; and consequently not receiving its Light by the Irradiation of any other Body upon it, but having its Light in it self, cannot suffer any such Defect of Light truly and really. Its Light may indeed be intercepted or hindered from coming to us by the Interposition of some opacous Body between Us and the *Sun*. But then it is the *Earth*, on which we are, not the *Sun*, that is deficient of Light, or *in an Eclipse*; and the opacous Body, whose Interposition between the Sun and Earth, causes the Earth to be thus in an Eclipse, is the Moon. Wherefore the Explanation of this *Phænomenon* depending

46 *Of the Annual Phænomena, &c*
pending on the Motion of the Moon,
it will be requisite to speak first of
that; after which I shall in a distinct
Chapter explain the Eclipses both of
the Sun (as it is commonly called)
and also of the Moon.



C H A P.

C H A P. IV.

Of the Phænomena relating to the Moon.

THE Moon is a *secondary* Planet, I.
 forasmuch as she moves round *The Moon,*
a *secondar-*
 the Earth primarily and immediately; ry Planet.
 and round the Sun only in a *secondary*
 Manner, *viz*, as she moves round the
 Earth, which moves round the Sun.

A *Period* or Single Revolution of 2.
 the Moon round the Earth from any A Periodi-
 Point of the *Zodiack* to the same, is cal Month,
 called the Moon's (*) *Periodical* Month; what.
 and consists of 27 Days, 7 Hours, and
 3 Quarters.

The Time from one *Synod* or Con- 3.
 junction of the Sun and Moon to A Synodi-
 another, is called the Moon's (*) *Sy-* cal Month,
nodical Month, and consists of 29 what.
 Days, $12\frac{3}{4}$ Hours.

(**) The Words *Period* and *Synod* are both of *Greek*
 Extraction, the former denoting a going Round a
 Thing, the latter a *Meeting* together of two or more
 Things.

The

4.
The Syn-
nodical
Month,
why longer
than the
Periodi-
cal.

The Reason of the *Synodical* Month being so much longer than the *Periodical*, is illustrated *Fig. 8*, where the Circle S denotes the Sun, the Circle T $\odot$ the *Orbit* of the Earth, T the Place of the Earth in the said *Orbit*, the Circle M $\circ$ the *Orbit* of the Moon; M or *m* two several Places of the Moon in her *Orbit*, the outermost and greatest Circle the *Zodiack*. Now let the Earth T be supposed in the first of *Libra*, and the Moon to be in her *Orbit* at M (in a right Line between the Earth and the Sun, and so) in *Conjunction* with the Sun in the first of *Aries*. The Moon moving thence Eastward, or according to the Series of the Signs, after 27 Days and 7 Hours and 45 Minutes, appears to us again in the first of *Aries*, i. e. at the point M of her own *Orbit*, in the second Position of the Earth. For in the mean while the Earth has also moved almost a whole Sign Eastward, viz. almost to the End of *Libra*. And hence the Moon M, though come again to the first of *Aries*, is almost a whole Sign Westward of the Sun. This is represented by the two prick'd Lines, whereof that from M (in the second Position

Position of the Earth) to γ represents how the Moon appears then to us in the First of *Aries*, while the other Line from m through S to the End almost of γ represents how the Sun appears at the same Time to be almost out of *Aries*, and so almost a whole Sign Eastward of the Moon. Wherefore the Moon must still move so much further, *viz.* from M to m in her own *Orbit*, before she will be in *Conjunction* again with the Sun. In going of which to overtake the Sun, is taken up the Time, whereby the *Synodical* Month exceeds the *Periodical*, *viz.* 2 Days, 5 Hours.

It is the *Synodical* Month, which is principally made Use of in Computation of Time. Forasmuch as the several Parts of this Month are sensibly to be distinguished by the several *Phases* or *Appearances* of the Moon, respectively belonging thereunto.

The several *Phases* of the Moon are accounted for thus. The Moon is conceived to be an opacous Body, *i. e.* a Body which receives its Light from the Sun. It is also spherical, and consequently has always one Half of it enlightened, namely, that Hemisphere

5.

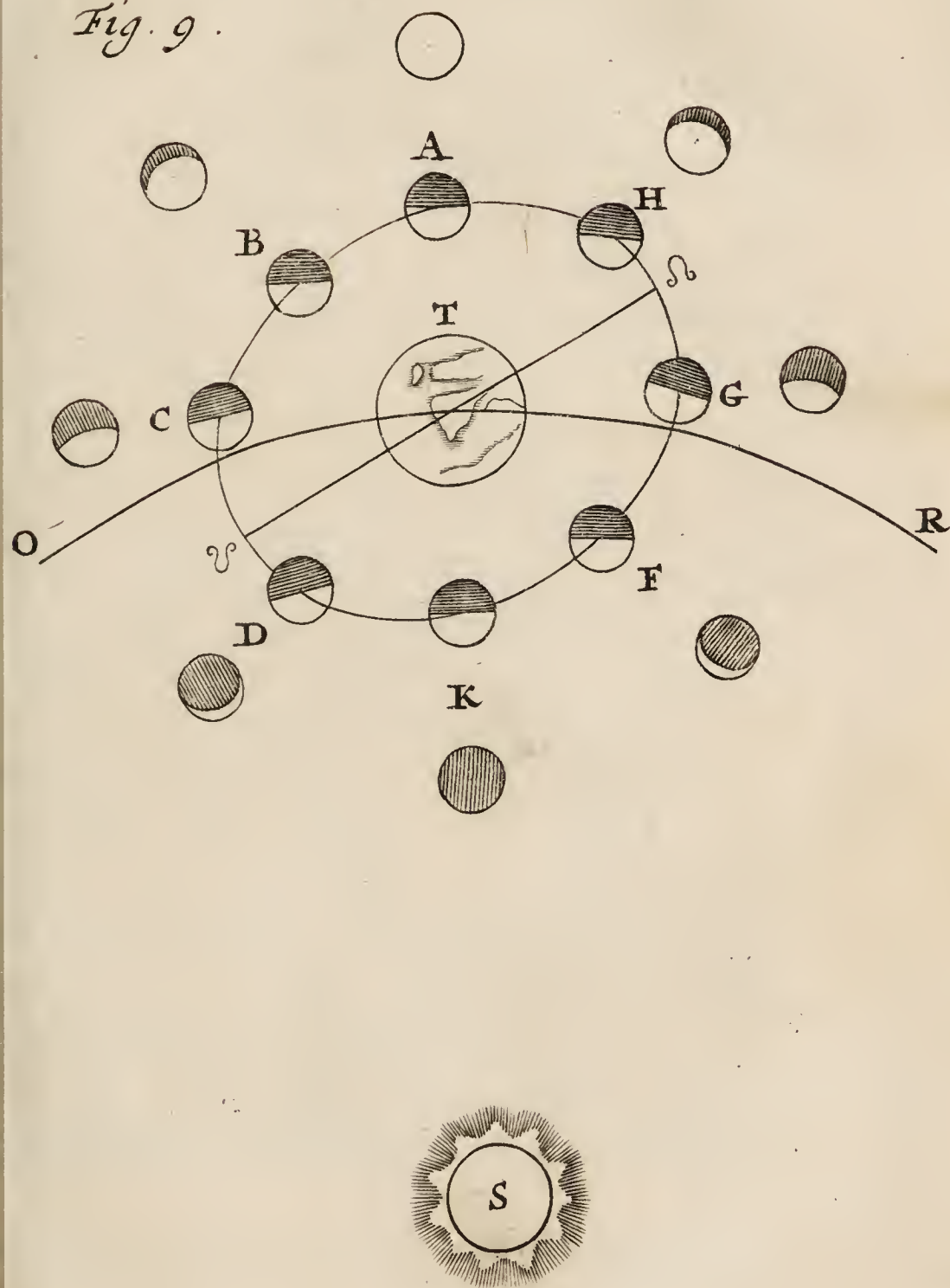
The Synodical Month of chief Regard.

6.

The several Phases of the Moon accounted for.

sphere which is towards the Sun
 Now from the Hemisphere being
 seen by us, sometimes more sometimes
 less of it, arise the several Phases
 of the Moon; for the better Under-
 standing whereof it is to be further
 observed, that although the Moon be
 a spherical Body, yet the enlightened
 Portion of it, which is seen by us,
 appears by Reason of its Distance as
 if the Moon had a plain Surface. All
 which is illustrated, *Fig. 9*, where S
 denotes the Sun, T the Earth, O T R
 Part of the Earth's *Orbit*, A C K G the
Orbit of the Moon, on the several
 more remarkable Points whereof, *viz.*
 A, B, C, D, K, F, G, H, is repre-
 sented the Moon with its enlightened
 and darkened Hemisphere; and at
 each Point so much of the enlightened
 Hemisphere, as is within the Circle
 A C K G, is seen by us; but it ap-
 pears to us, not as it is there repre-
 sented, (*i. e.* not as a Portion of an
 Hemisphere,) but as a Portion of
 some plain circular Surface, as is re-
 presented by the several little circular
 Draughts respectively adjoining. This
 being premised, 'tis evident from the
 said Figure the 9th, that the Moon
 being

Fig. 9.



being at A, all its enlightened Hemisphere is towards the Earth, and seen by Us, whence the Moon appears to us with a full Orb, (*i. e.* with a plain circular Surface all enlightened,) which Phasis or Appearance is therefore stiled the *Full Moon*. The Moon being moved to B, 'tis evident, that only some Part of its enlightened Hemisphere will be towards the Earth, and so seen by us; whence the Moon will appear like a (†) plain circular Surface, not fully enlightened, but somewhat defective of Light on that Side which is from the Sun, and consequently will appear gibbous. The Moon being moved to C, just Half of its enlightened Hemisphere will be towards the Earth, and seen by Us: whence the Moon will appear then with an half Orb, or with a semi-circular Surface. The Moon being moved to D, a very little Portion of its enlightened Hemisphere will be seen by Us, and this will appear horned, the Horns bending from the Sun, and

(†) Hence the Face of the Moon is called *Discus*, as resembling a flat round Dish.

so (||) westward. The Moon being come to K, none of its enlightened Hemisphere will be towards the Earth, and so the Moon will not be seen by us, and then it is said to be *New Moon*; because the Moon will a little after appear anew in F, and that again horned, the Horns now likewise bending from the Sun, and so (||) eastward. After which the Moon will appear at G with an half Orb again, (as at C;) and at H gibbous again, (as at B;) and so will proceed to A, where it will be again Full Moon. And so the Moon will have undergone her several Phases; which though they somewhat vary every Day, nay every Hour; yet are usually taken Notice of, and distinguished only in the fore-mentioned Points.

7.
The remarkable
Phases of
the Moon,
five.

Hence the remarkable Phases of the Moon are five; whereof the two principal are the *New* and the *Full* Moon. The three other, viz. the *Gibbous*, *Half*, and *Horned* Moon,

(|||) Hence the memorial Verse,
Dextra cavum Veteris complebit, Lava Recentis.

occur

occur both between the New and Full Moon, and also between the Full and New Moon; only in a different Order. Between the New (which is also called the *Change*) and the Full, the Moon is first horned, then halved, and lastly gibbous; whereas between the Full and Change, she is first Gibbous, then Halved, and lastly Horned.

When the Moon is thus Horned, 8.
 or a little before and after the New Moon, (*viz.* when the Moon is at the Points D and F,) besides its bright Horns, the Moon has a faint Light, whereby all the Rest of its Discus is rendred discernable. This faint Light has been thought by some to be the Moon's Native proper Light; but it is now generally supposed by the learned in Astronomy to be no other than a Reflection of the Sun's Rays upon the Moon, the Earth's Position being such at this Time, as very well suits to such a Reflection, as may be seen, *Fig. 9.* And this Supposition is rendered still more probable, because that as soon as the Moon is moved beyond the Limits of such a Reflexion

The faint Light which is seen in the whole Discus of the Moon, a little before and after its Change; whence supposed to arise.

E 3 from

from the Earth, the fore-mentioned faint Light ceases.

9.
Of the
Moons A-
pogee and
Perigee,
&c.

What has been afore observed of the Sun, is also observed by the curious of the Moon; namely, that in one Part of her *Orbit* she appears lesser, and (*cæteris paribus*) slower; in the opposite Part bigger and swifter. Which *Phænomena* may be solved after the like manner, as are the like *Phænomena* of the Sun; viz. by the Moon's Motion in an elliptical *Orbit*, having one of its Focus's in the Center of the Earth. Accordingly this may be illustrated by *Fig. 7*, supposing the Ellipsis *A P* (which there represents the *Orbit* of the Earth) to represent the *Orbit* of the Moon and the Circle *S* (which there represents the Sun) to represent the Earth. For then *A* will represent the Moon's *Apogee* or greatest Distance from the Earth, when she will appear lesser; and *P* her *Perigee* or least Distance, when consequently she will appear greater. And because she is longer in passing the greater Segment of her *Orbit* between her *Apogee* and that Focus of her *Orbit*, which is in the Center of the Earth, than the lesser Segment

ment between the said Focus and her *Perigee*; therefore she will appear to move slower, while she passes along that Half of the *Zodiack*, which answers to the greater Segment of her *Orbit*; and swifter, while she passes the other Half of the *Zodiack*, answering to the lesser Segment of her *Orbit*.

Among the *Phænomena* of the Moon more obvious to our Sense, there remains only the Eclipse of the Moon to be spoken of, which shall be explained in the following Chapter.

C H A P. V.

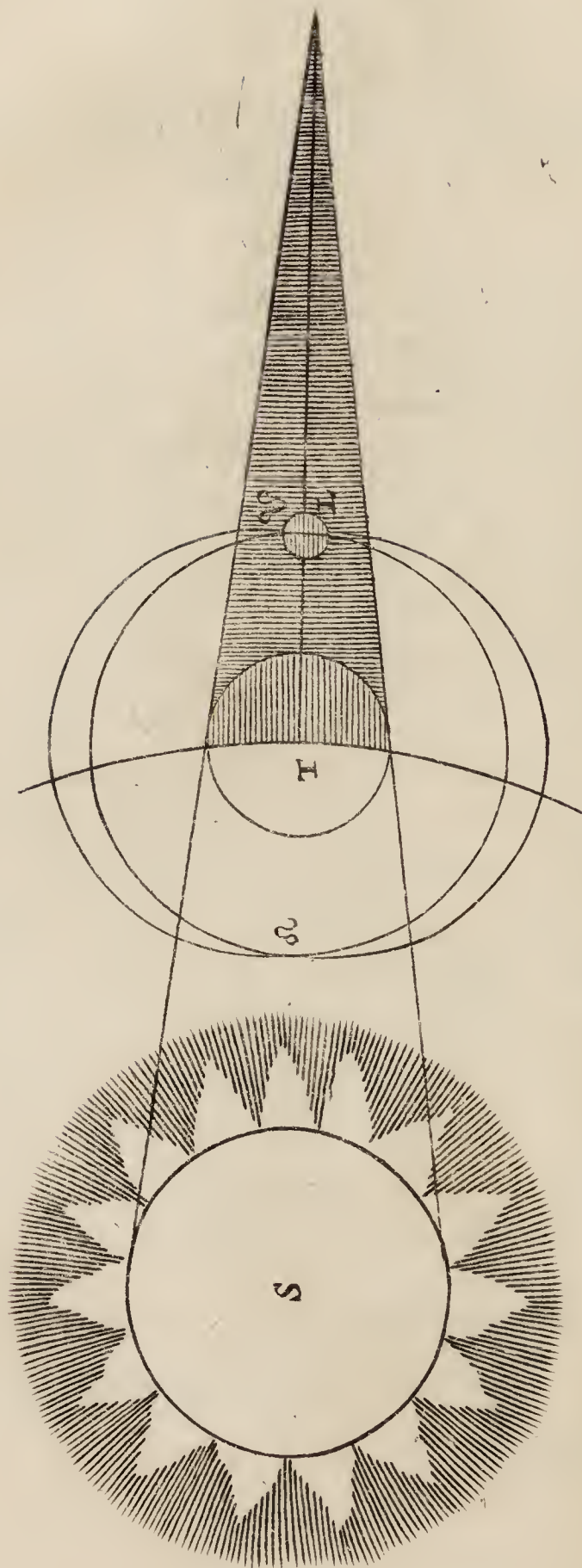
Of the Eclipses of the Sun and Moon.

An Eclipse
of the Sun
and Moon,
what.

TH E Eclipses of the Sun and Moon are here spoken of together, because as they arise from like Causes, so are they to be explained much after the same Manner. For it is to be remembred, that it has been afore (*) observed, that what is commonly called the Eclipse of the *Sun*, is in reality the Eclipse of the *Earth*. Wherefore, the Earth and Moon being both opacous Bodies, which receive Light from the Sun, an Eclipse of the Earth (commonly called an Eclipse of the Sun) is no other than a Deficiency of Light on the Earth, by the Moon's coming between the Earth and the Sun, so as to hinder the Rays of the Sun from falling on the Earth; just as an Eclipse of the Moon is a

(*) Chap. 3 Sect. 14.

Fig. 10.



Deficiency of Light in the Moon, by the Earth's coming between the Moon and Sun, so as to hinder the Rays of the Sun from falling on the Moon.

Hence it is evident from *Fig. 9*, ^{2.} that all Eclipses of the Earth happen ^{Eclipses of the Sun} at the Change of the Moon, because ^{and Moon,} then only it is that the Moon comes ^{when hap-} between the Earth and the Sun; and all the Eclipses of the Moon happen at the Full of the Moon, because then only 'tis that the Earth can come between the Moon and the Sun.

It is to be shewn further, for what ^{3.} Reasons there is not an Eclipse of the ^{Why not} Earth at ^{at every} every Change, but only at ^{Change or} some certain Changes of the Moon; ^{Full of the} nor an Eclipse of the Moon at ^{Moon, but} every ^{only at} Full, but only at ^{some cer-} some certain Full Moons. It is then to be known, that ^{tain Ones.} the Orbit of the Moon crosses the *Ecliptick*, so as to make an Angle of 5 Degrees Inclination. The Points where the Moon crosses the *Ecliptick*, are called the *Noes of the Moon*, and are denoted, *Fig. 10*, by these Characters Ω and Υ ; the former of which is called *the Dragon's Head*, the latter *the Dragon's Tail*. The Moon crosses the *Ecliptick* at the Dragon's Head, when

Of the Eclipses.

when she is entring on that Part of her *Orbit*, which inclines northward from the *Ecliptick*; and she crosses the Dragon's Tail, when she is entring on that Part of her *Orbit*, which inclines Southward from the *Ecliptick*. Now the Nodes being the only two Points, where the Moon crosses the *Ecliptick*, hence there can be no Eclipse of the Earth, but when the Moon happens to Change in or near one of the Nodes; because in this Case only, the Moon at her Change comes so between the Earth and the Sun, as to intercept the Rays of the Sun, and keep them from the Earth. And in like manner, there can be no Eclipse of the Moon, but when the Moon happens to be at Full, in or near one of the Nodes; because in this Case only, the Earth comes so between the Moon and the Sun, as to intercept and hinder the Rays of the Sun from falling on the Moon.

4. In an Eclipse of the Earth, the Moon by intercepting the Rays of the Sun, casts a Shadow on the Earth. And in an Eclipse of the Moon, the Earth by intercepting the Rays of the Sun, casts a Shadow on the Moon.

The Shadow, in Eclipses of the Sun and Moon, of what Figure.

These

These Shadows are of a (†) conical Figure, growing narrower and narrower, the further they go from the Earth and Moon, till at length they end in a Point, and so cease. Were these Shadows, either of a (||) cylindrical Figure, *i. e.* of an equal Thickness all along; or of a (||) conical Figure, but inverted the other Way, *i. e.* did they grow thicker and thicker, the further they are extended, then they would be extended *in infinitum*. But now 'tis certain, that the Shade of the Earth does not extend to the *Orbit* of the primary Planet *Mars*; forasmuch as when the Earth is directly between the Sun and *Mars*, the latter is not eclipsed, as it must necessarily be, did the Shade of the Earth reach to the *Orbit* of *Mars*.

It being thus demonstrable, that 5.
the Shadow of the Earth ends in a Point, before it comes to the *Orbit* of *Mars*; hence it is also demonstrable that the Sun is bigger than the Earth; forasmuch as an opaque Body can't

The Sun
how de-
monstrated
to be big-
ger than
the Earth,
and the
Earth than
the Moon.

(†) As in *Fig. 13.*

(|||) This is evident from *Fig. 11. and 12.*

cast such a conical Shade, but when it is lesser than the lucid Body, whose Rays it intercepts. For if the opacous Body be equal to the lucid Body, then the Shadow will be of an equal Thickness all along. And if the opacous Body be greater than the lucid Body, then the Shadow will indeed be of a conical Figure, but in an inverted Manner, that is, so as that the conical Shade will grow wider and wider, as it goes further and further. And as the Sun may be thus demonstrated to be bigger than the Earth, so the Earth may be demonstrated to be bigger than the Moon; forasmuch as the Moon can be totally Eclipsed. For this could not be, was not the Cone of the Earth's Shadow, even in that Part of it which the Moon passes through in a total Eclipse, bigger than the Moon, though it be lesser than the Earth itself: what is here said is illustrated, Fig. 11. 12, 13.

6.

The Great-
ness of an
Eclipse de-
pends in
one Respect
on the

The Shadows of the Earth and Moon being thus of a conical Figure, it is obvious that an Eclipse either of the Earth or of the Moon will be (*ceteris paribus*) greater or longer,

Fig. 11.

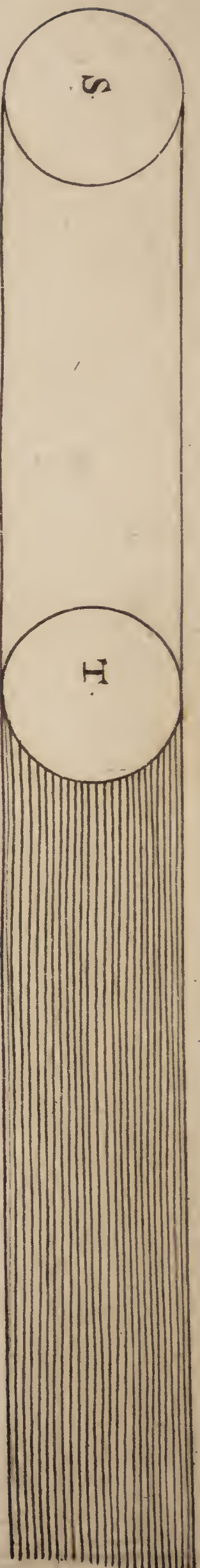


Fig. 12.

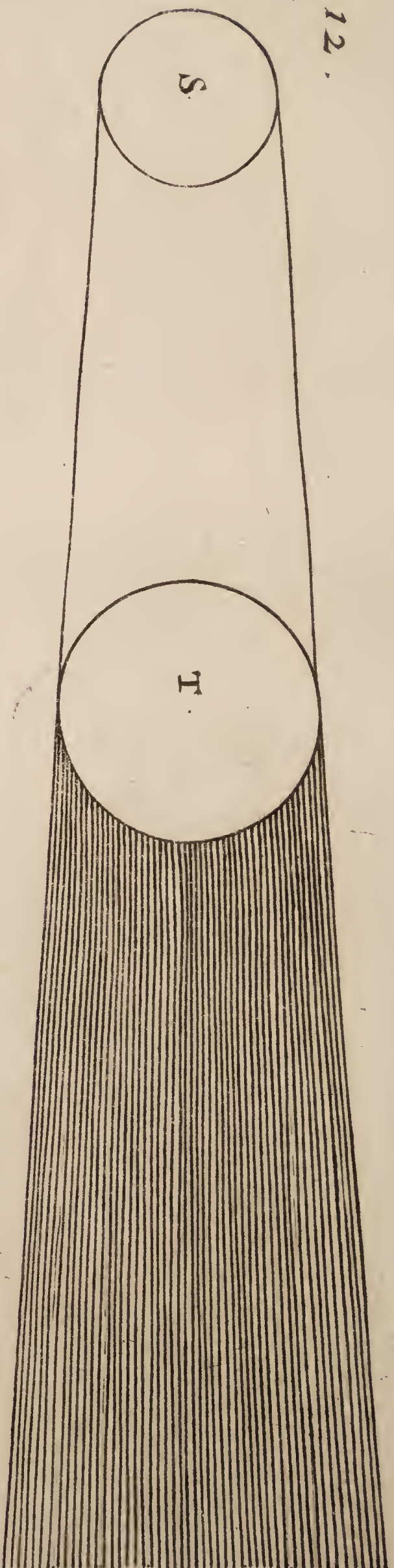
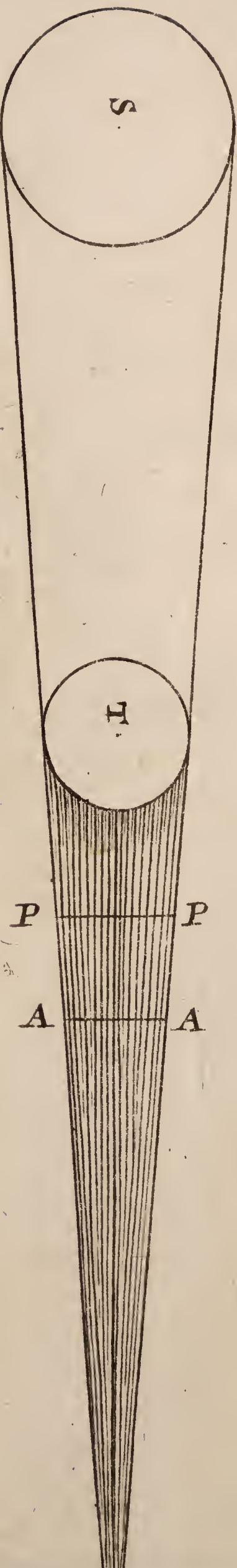


Fig. 13.



Pag. 62.

Fig. 14.

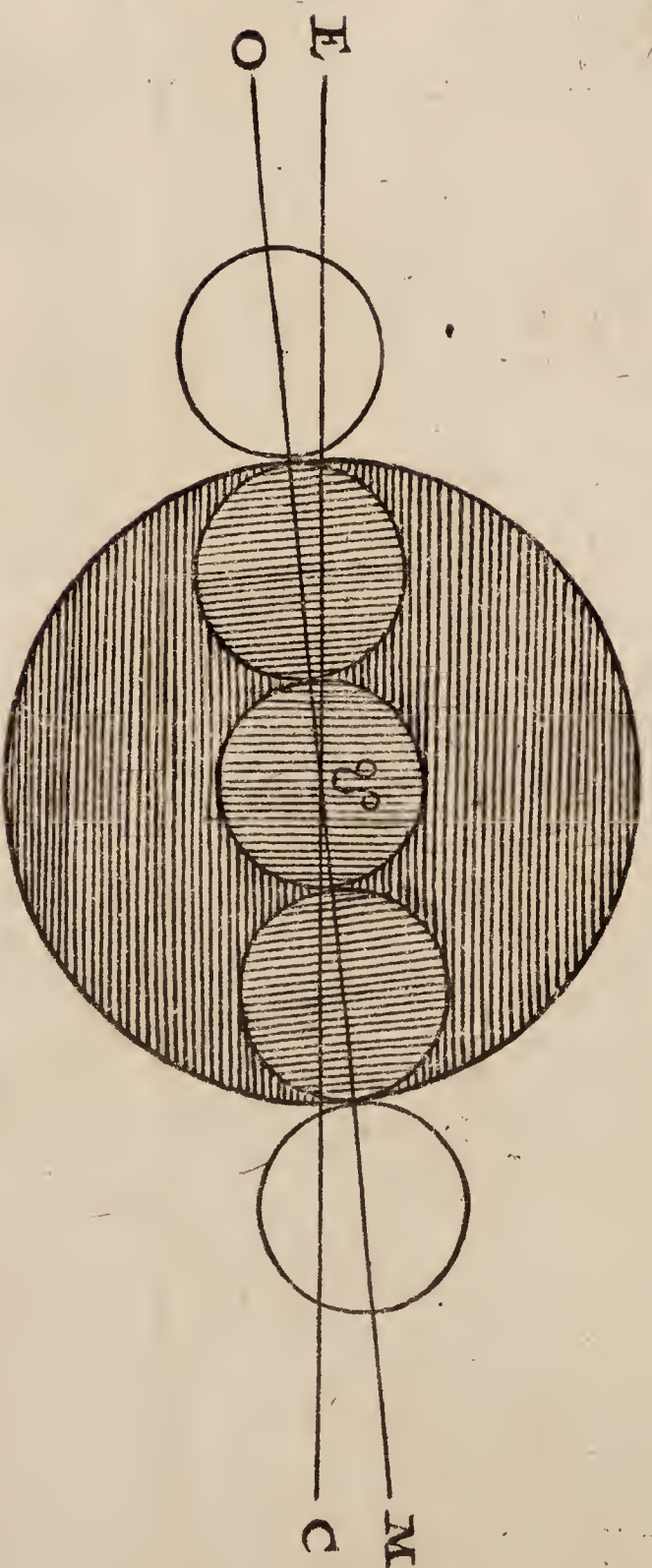


Fig. 15.

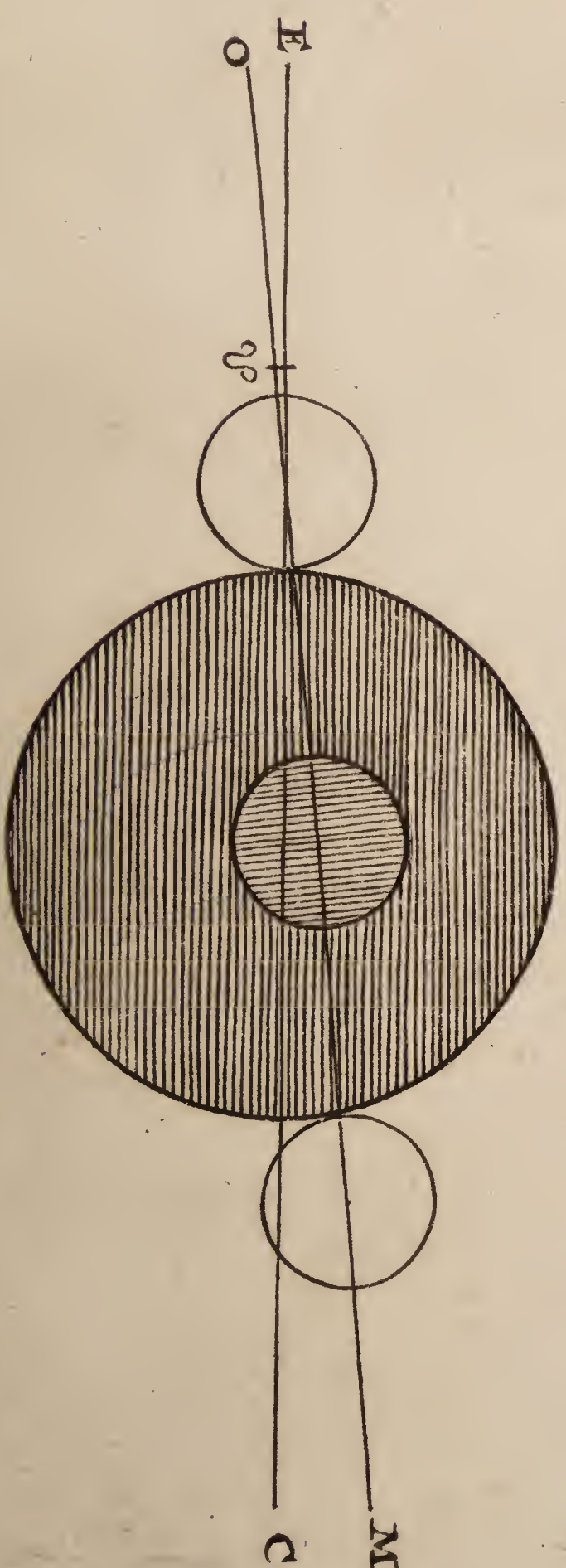
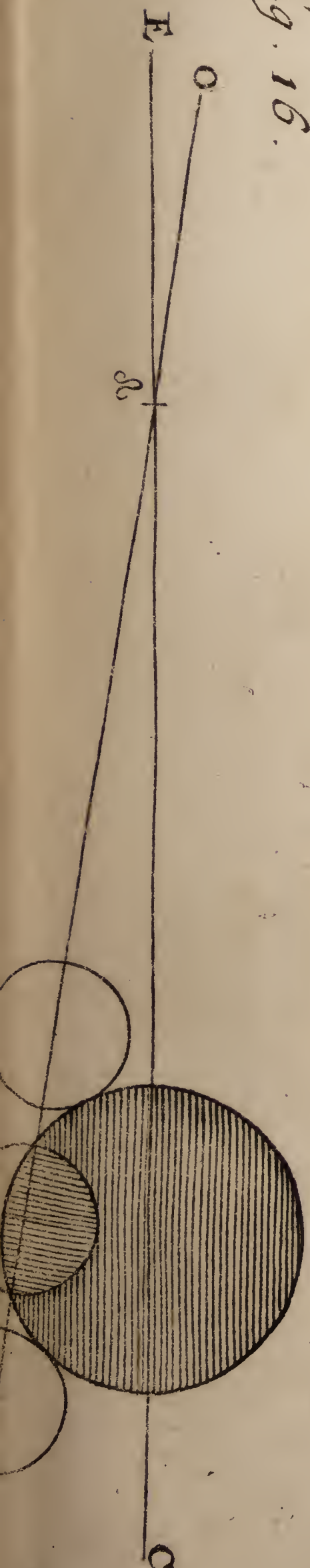


Fig. 16.





longer, when the Moon is in her *Perigee*, than when she is in her *Apogee*. For the Moon if she be eclipsed in her *Perigee*, meets with a thicker Part of the Line of the Earth's Shadow, then if she be Eclipsed in her *Apogee*; as is obvious from *Fig. 13*, where the Line P P denotes the Moon's Passage through the Shadow in her *Perigee*, and the Line A A in her *Apogee*. And in like manner, if the Earth be eclipsed when the Moon is in her *Perigee*, it meets with a thicker Part of the Cone of the Moon's Shade, than it does if it be eclipsed when the Moon is in her *Apogee*; as is obvious also from *Fig. 13*, taking the Circle T to denote the Body of the Moon; and the Line P P to denote the Passage of the Earth through the Shade of the Moon in her *Perigee*, and A A to denote the like in the *Apogee* of the Moon.

But the Variety, that is observed in Respect to the Greatness and duration of Eclipses, does principally arise from the Moon's being then more or less distant from a Node or the *Ecliptick*. Which shall be illustrated,

Moon's being in her Apogee or Perigee.

7.
But principally on the Moon's Distance from her Nodes.

Of the Eclipses

strated, first in reference to the Moon, then in reference to the Earth.

8. An Eclipse of the Moon, considered as to its *Greatness*, is either *Total*, when the whole Moon is eclipsed; or *Partial*, when only a Part of it is eclipsed.

9. As to *Duration*, every total Eclipse holds longer than any partial One. And, as some partial Eclipses are of longer Duration than other Partial, so some total Eclipses are of longer Duration than other Total. Such total Eclipses, as are of the longest Duration, happen when the Moon is in a Node, and are called *central* Eclipses, because, as the Moon, passes through that Section of the Cone of the Earth's Shadow, which meets with the *Orbit* of the Moon, the Center of the Moon passes exactly through the Center of the said Section or Shadow.

10. This is illustrated, *Fig. 14*, where the shaded Circle represents the Section afore-mentioned of the Earth's Shadow; O M the *Orbit* of the Moon, E C the *Ecliptick*. 'Tis evident, that the Moon in this Case crossing a Diameter of the shaded Circle, makes the longest

longest Stay she can make in the Shadow of the Earth; and this Stay is computed about four Hours long. Whereof the Moon takes up one Hour from her Beginning to enter into the Shadow, till she is quite immersed therein; two Hours more she continues quite immersed, passing on through the Shadow; and the fourth Hour is taken up from her first Beginning to come out of the Shadow, till she is got quite free of it. Whence by the Way it appears, that the Wideness of the Shade is equal to about three Diameters of the Moon.

In Fig. 15, is represented a *total*, but *not-central* Eclipse; which happens when the Moon meets with the Shadow of the Earth, though not at a Node, yet at a small Distance from it. And as it is obvious from the same Figure, that every total, but not central Eclipse must be of a shorter Duration than a central, so it is also obvious, that one total, but not central Eclipse will be longer than another, in Proportion to the Moon's greater or less Distance from a Node at that Time.

II.

A Total,
but Not-
central E-
clipse of
the Moon

In

12.

A partial
Eclipse of
the Moon.

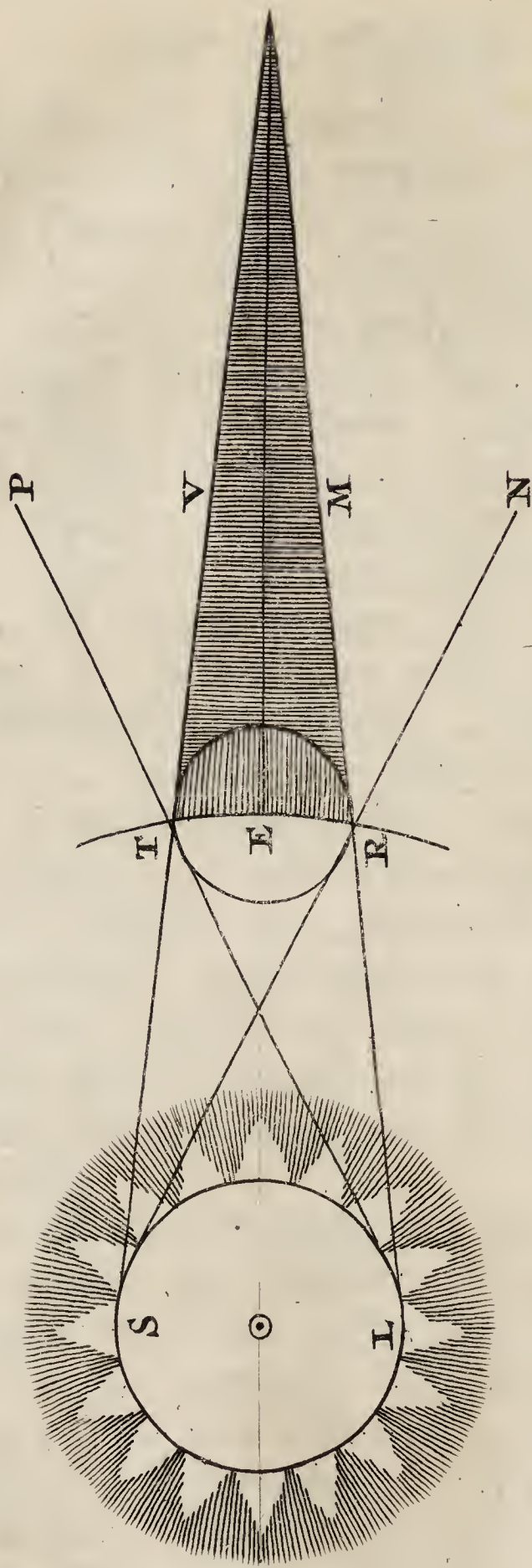
In *Fig. 16.* is represented a partial Eclipse. And it is evident from the same Figure, that as any total Eclipse must be of longer Continuance than any partial; so one partial Eclipse is of longer Continuance than another, according as the Moon is then more or less distant from a Node. It is also obvious, that the longer a partial Eclipse is, so much greater is it, *i. e.* so much greater Part of the Moon is darkned or passes through the Shadow of the Earth. Hence it is usual to conceive the Moon's Diameter, as divided into twelve Parts, called *Digits*; by which the Greatness of partial Eclipses are measured and distinguished; they being said to be of so many Digits, as there are such twelve Parts covered by the Shadow of the Earth, when the Eclipse is at greatest.

13.

Of the Pen-
umbra in
Eclipses of
the Moon.

In all these Eclipses of the Moon, she enters the western Side of the Shadow with her eastern Side; and so it is her western Side which last quits the eastern Side of the Shadow, when the Eclipse ceases. But now as the eastern Limb or Side of the Moon draws towards the Shadow; before
it

Fig. 17.



it enters the thick Shadow it self, and is quite darkened, it grows more and more dim, as it comes nearer and nearer to the Shadow. Which Dimness arises from a Penumbra or Dusky-ness, which always attends such Shadows, and encompasses them all round. Thus *Fig. 17*, T U M R represents the Shadow, (where comes not any Part of the Sun's Light,) which is encompassed all round with the Penumbra U T P M R N, where only some Part of the Sun's Light is intercepted by the Earth. And this Penumbra is more dim towards T U and M R the edges of the perfect Shadow, because the Rays of a lesser Portion of the Sun, and so fewer Rays reach thither; and less dim towards T P and R N, where more Rays fall; and beyond which Limit, all the Rays of the Sun have a free Course.

In some Eclipses the Moon quite disappears in the perfect Shadow. At other Times she appears even in the Midst of the perfect Shadow, of a reddish Colour like a burnt Brick. Which reddish Colour is supposed to arise from the Rays of the Sun, ei-

14.
The Moon why appear of a reddish Colour in total Eclipses.

Of the Eclipses

ther refracted in the Atmosphere about the Earth, or reflected to the Moon by Particles flying without the Shadow of the Earth; or else to arise from the Illumination of the Stars, or all these Causes together.

15. There happen most Years two Eclipses of the Moon at least. For there being two Nodes, wherein the Moon crosses the *Ecliptick*, and which move contrary to the Series of the Signs, and the Earth going round the *Ecliptick* every Year the other Way, or according to the Series of the Signs; hence it is obvious, that the Earth must meet the Moon's Nodes every Year. If therefore it happens then to be Full Moon, there must be a central Eclipse. If it be not then Full Moon, but more than ten Days (and more than fifteen it cannot be) either before or after a Full Moon; yet so great is the Inclination of the Moon's *Orbit* to the *Ecliptick*, and so great is the Thickness of the Cone of the Earth's Shadow, that the Moon will scarce miss going through some Part of the Shadow; and consequently there will be at least a partial Eclipse. But if the Earth happens to meet

How many
Eclipses of
the Moon
usually
happen in
a Year.

meet a Node of the Moon on the very Day of a New Moon, or one or two Days before or after, (which happens but seldom) in this Case the Moon will be far enough to avoid the Shadow of the Earth, both in the foregoing and also following Full Moon; and so there will be no Eclipse of the Moon that half Year. And this may suffice in Relation to the Eclipses of the Moon.

Proceed we now to the Eclipses of the Earth, which are commonly called Eclipses of the Sun, inasmuch as the Moon, which more or less covers the Sun, being not seen by us, the Deficiency of Light appears to our Sight as in the Sun it self. Whence an Eclipse of the Sun is distinguished also into a *total* Eclipse, wherein the Moon covers the whole Body of the Sun from us; and a *partial* Eclipse, wherein the Moon covers only a Part of the Sun.

But it is to be well observed, that although an Eclipse of the Sun be in reality an Eclipse of the Earth; yet what is called a *total Eclipse of the Sun*, is not to be conceived as in reality a *total Eclipse of the Earth*; or

16.

An Eclipse
of the Sun
Total or
Partial.

7.

Of a Total
Eclipse of
the Sun.

Of the Eclipses

that the whole upper and opposite Hemisphere of the Earth is then deprived of the Sun's Light, as in a Total Eclipse of the Moon is the whole opposite Hemisphere of the Moon. The Reason of which Difference is this. The Earth being bigger than the Moon, the Cone of its Shadow is big enough to involve the whole opposite Hemisphere of the Moon in its Darkness. Whereas the Moon being less than the Earth, the Cone of her Shadow will involve at once only a small Tract (CD in *Fig. 18.*) of the opposite Hemisphere of the Earth, so as to hide the whole Sun from the Inhabitants thereof; and consequently there will appear only to these a Total Eclipse of the Sun, whilst to the Inhabitants of the adjoining Tracts BC, and DE, the Sun will appear to be but partially Eclipsed; and beyond these on each Side, there will be no Eclipse at all of the Sun, as is evident from the same *Fig. 18.*

18. The Moon moving from West to East, that is, from $\sphericalangle$ through m to $\dagger$, hence her eastern Limb appears to us first to cover the western Limb of the Sun. And when there is a Total

The Sun continues totally Eclipsed, but a very short While.

Fig. 18.

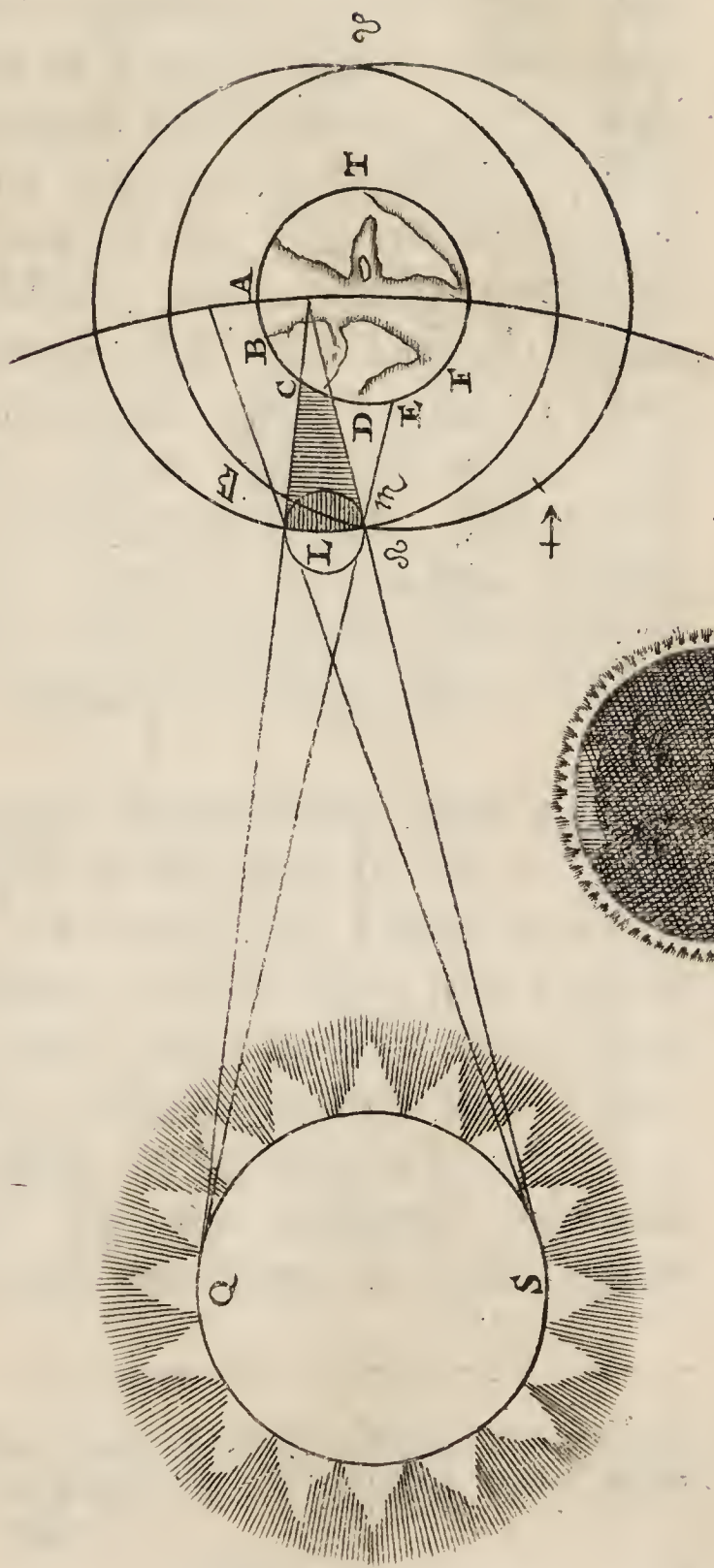
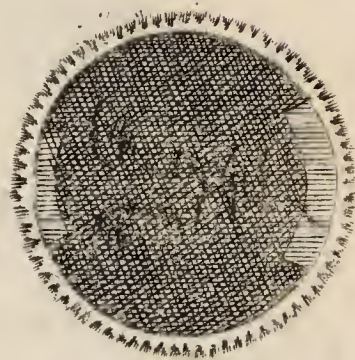


Fig. 19.



Total Eclipse of the Sun, for the Time that the Moon covers all the Sun from us, it is so dark, as that sometimes the Stars have appeared, and there has been need of Candle-light. But then this Darknefs lasts but a very little While; for no sooner is the (*) Discus or Face of the Sun quite covered by the Moon, but almost presently some Part of the said Discus begins to be uncovered again, and a very little Part of it being so uncovered gives a considerable Light. All which Particulars relating to a Total Eclipse of the Sun were Actually exemplify'd here in *England* no longer, than *April* 1715. ago

It happens sometimes, that a Central Eclipse of the Sun is not a Total Eclipse; but about the Limb or Edge of the Moon, which looks like a black or dark Spot, may be seen the Limb of the Sun, which appears like a Circle of Light, as in *Fig. 19.* This is occasioned by the Shadow of the Moon being too short to reach quite

19.
A central
Eclipse of
the Sun
may be not
a Total.

(*) The Sun's Face is called its *Discus*, for the like Reason, as the Moon's Face is so called, taken Notice of *Chap. 4. Sect. 6.*

Of the Eclipses

to the Earth; and this Shortness of the Moon's Shadow may be occasioned, either by the Moon being in her *Apogee*, or else by the Rays of the Sun, which pass by the Edge of the Moon, being bent by Inflection, and so shortening the Shade of the Moon.

20. *Of the Number of Eclipses of the Sun in a Year.* The greatest Eclipse of the Sun (wherein the Shadow of the Moon passes along the Middle of the Earth) is, when the Moon happens to be in a Node at the Moment of her Change. If she be not far from a Node, the Shadow of the Moon, or at least some Part of the Penumbra will fall on some Tract of the Earth, (as being large enough,) and will there make a Total, or at least partial Eclipse. And in this Respect there are more Eclipses of the Sun, than of the Moon. But in Respect of any one given Place of the Earth; there are much fewer visible Eclipses of the Sun than of the Moon, for the Shade of the Moon is lesser than the Shade of the Earth; and consequently the former will not so often involve any given Place of the Earth, as the latter will some Part of the Moon.

It

of the Sun and Moon.

71

It remains now only to observe, 21
that the *Ecliptick* is so called, because The Eclip-
all the fore-mentioned Eclipses hap- tick, why
pen, only when the Moon is in or so called.
near a Node, *i. e.* in or near the
Plane of the *Ecliptick*. And as all
Eclipses of the Sun and Moon happen
in the *Ecliptick*, so likewise do the
Eclipses of the other Planets, of which
we come now to speak.



F 4

CHAP.

C H A P. VI.

Of the Phænomena of the primary Planets, of Saturn, Jupiter, Mars, Venus, and Mercury; as also of the secondary Planets, or the Satellites of Saturn and Jupiter.

I.
The primary Planets distinguished into Superiour and Inferiour, with Respect to the Earth.

AS there are five primary Planets besides the Earth, so they are distinguished, by Reason of their Situation with Respect to the Earth, into *Inferiour* and *Superiour*. The former are such as move between the Earth and Sun, and are two, *Venus* and *Mercury*; the latter are such, as have the *Orbit* of the Earth between the Sun and their own *Orbits*, and these are three, *Saturn*, *Jupiter*, and *Mars*. This with their respective Order may be seen, *Fig. 1.*

2.
Hence arises some Difference.

Although both inferiour and superiour Planets agree in this, that the Planes of their *Orbits* cross the Plane of the *Ecliptick*; yet their different Situation

Fig. 20.

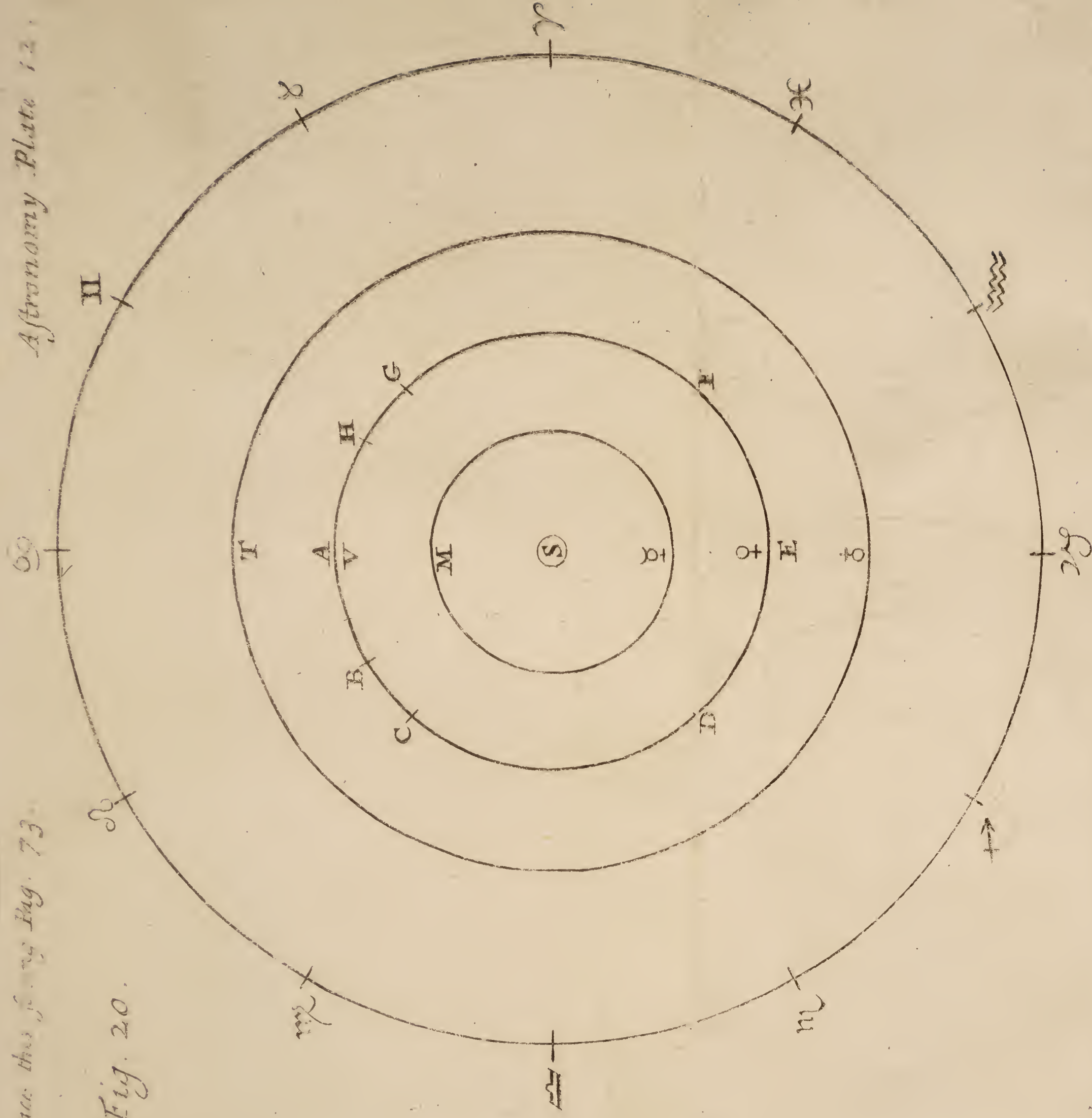


Fig. 21.

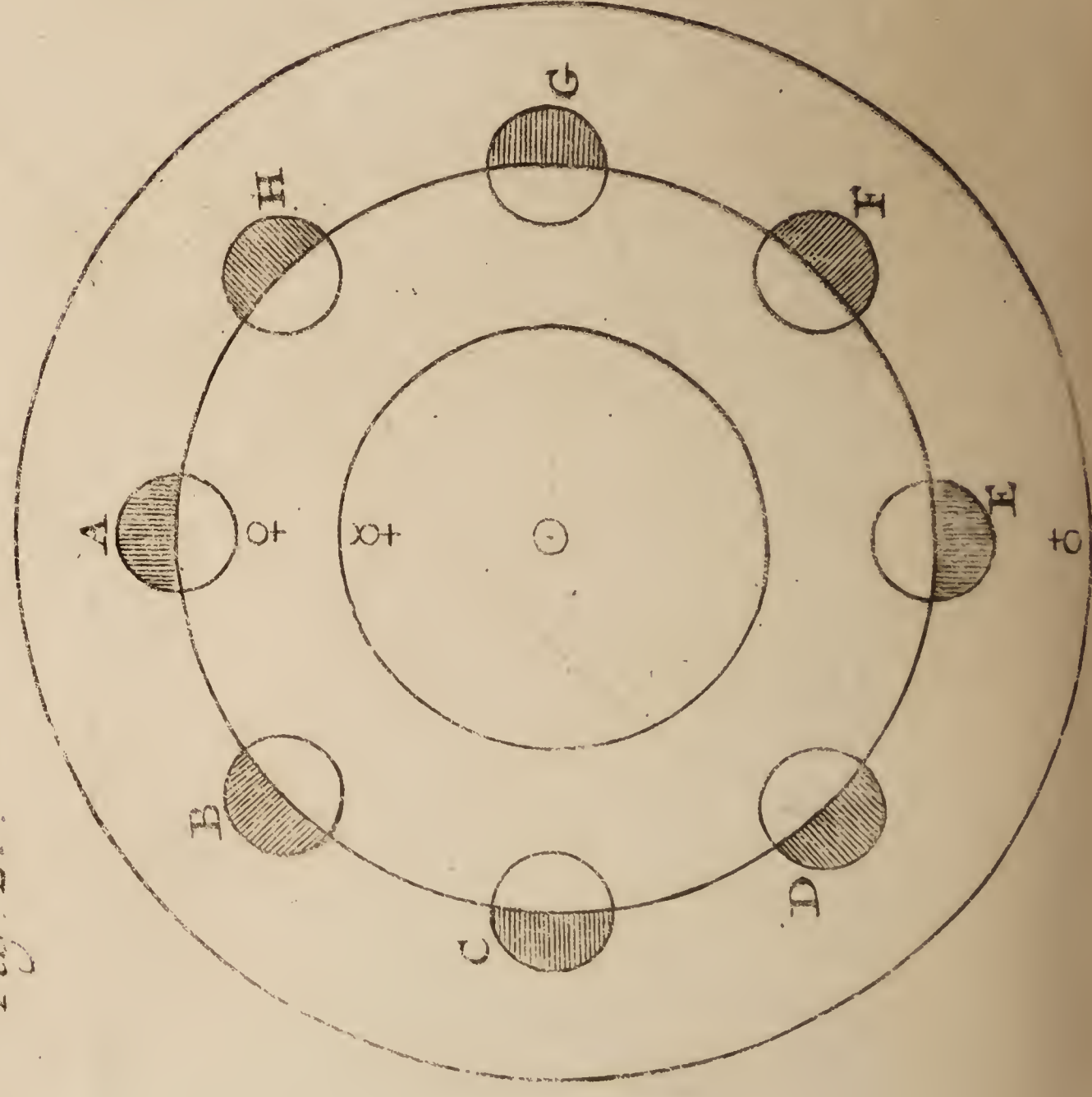
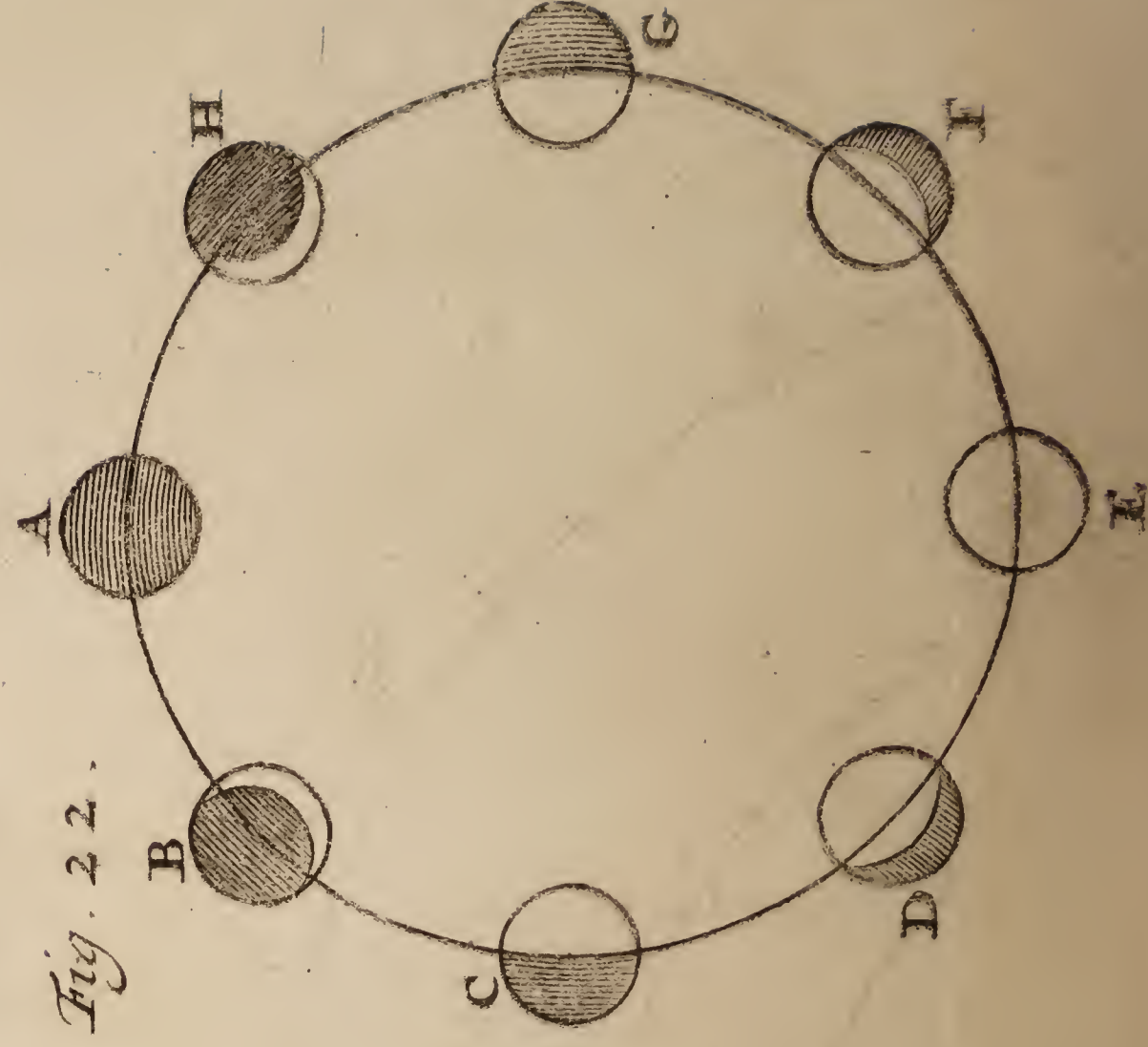


Fig. 22.



Of the Phænomena, &c. 73

Situation with Respect to the Earth as to their
occasions some Difference in the Phænomena.
Phænomena respectively belonging to
them.

I shall begin with the inferiour 3.
Planets, whose *Orbits* together with The inferi-
our Planet
the *Orbit* of the Earth and *Ecliptick* Venus,
are represented, *Fig. 20*, namely, why it ap-
pears some-
times to
M ☿ represents the *Orbit* of *Mercury*,
V ♀ of *Venus*, T the Earth in its *Or- move Di-
bit*, T ♂, the outermost Circle, the rectly,
sometimes
Ecliptick; the little Circle, S in the Backward,
Center, the Sun. Now *Venus* moving and some-
times to
in a lesser *Orbit* than the Earth, but stand still.
the same Way, *viz.* from West to
East; it is evident, that when *Venus*
is in D E F the more remote Part of
her *Orbit* from the Earth T, she will
appear to us in T to move according
to the Series of the Signs, (*viz.* from
♈ to ♎, &c.) and so to move *di-
rectly* forward. When *Venus* is come
to G, from thence to H, she will still
appear to move directly forward, but
slower than before; forasmuch as she
now moves as it were in a straight
Line towards T the Earth. As she
passes beyond H through A to B,
moving quicker than the Earth, she
will pass between the Earth and the
Sun,

Sun, and will seem to us on the Earth to move contrary to the Series of the Signs, (*viz.* from ϖ to $\nearrow$), and so to have a *retrograde* Motion, or to move backward. Between her direct and retrograde Motion, *viz.* about H, she will appear *stationary*, i. e. to stand still; forasmuch as the right Lines then joining the Earth, and *Venus* will for some Time continue parallel. And in like manner between her retrograde and direct Motion, *viz.* about B, she will appear a second Time to stand still. From what has been said 'tis obvious, that *Venus* when she is retrograde, as at A, is nearer the Earth, and therefore seems bigger; and on the other hand when she is direct, as at E, she is more remote from the Earth, and so (*cæteris paribus*) seems lesser.

4. The several Phases of *Venus*, according to her different Position with Respect to the Earth, are represented as they are in themselves, *Fig. 21.* Whence it is evident, that when *Venus* is at A, that is, most retrograde and nearest to the Earth, she does not appear to us, her dark Face being

ing towards us, and if she then happens to be in or near enough to a Node, she will pass directly between the Earth and Sun, and so seem as a spot in the Sun. Otherwise, if she be far enough from a Node, she will go on one side of the Sun, either Northward or Southward. At B she will appear horned, at C with an half Orb, at D gibbous, and at E (where she moves most directly, and is most remote from the Earth) with a full Orb; unless she be then in or near enough to a Node, in which Cases she will be hid from us by the Sun. After her Full, *Venus* undergoes the same Phases as afore, only an inverted Order, till she comes to her Change again. As *Fig. 21*, represents the several Phases of *Venus*, as they are in themselves; so *Fig. 22*, represents them, as they appear to us on the Earth; the correspondent Phases being denoted in both Figures by the same Letters, A, B, C, &c.

Lastly, *Venus* moving round the Sun at a lesser Distance than the Earth does, hence to us she appears as always accompanying the Sun; her greatest Elongation or Distance from the

5.

Why Venus appears always accompanying the Sun; and

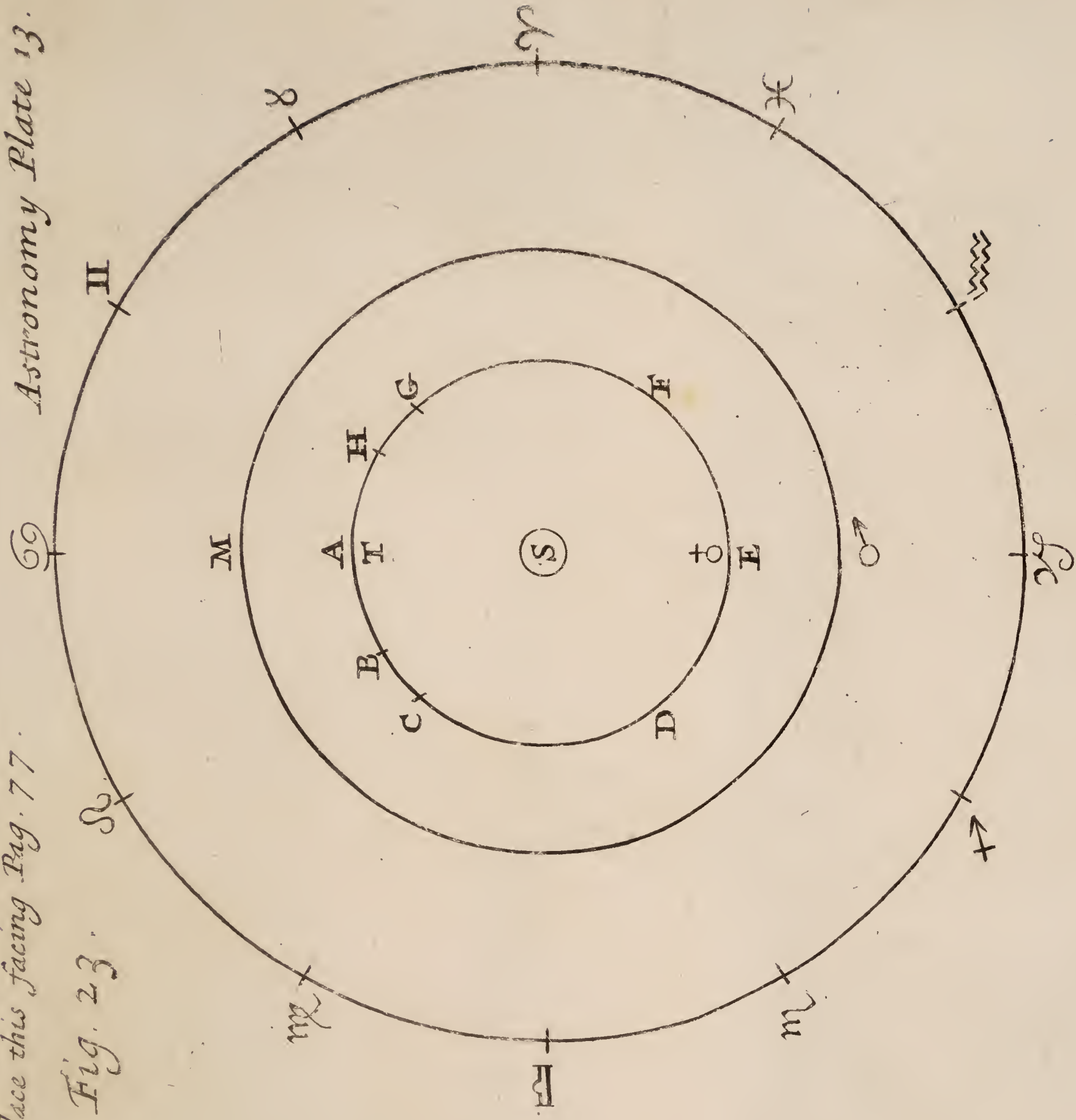
why called the Sun being about 45 Degrees, or a
Phospho- Sign and Half. When she appears
rus, and before the Sun in the Morning, and
Hesperus, so does as it were usher in Day-light,
&c. she is then called *Phosphorus* or *Luci-*
fer, or the *Morning Star*; when after
the Sun at Evening, then she is called
Hesperus or *Vesper*, or the *Evening*
Star.

6. What has been said and illustrated
of the concerning *Venus*, is also to be un-
Phænome- derstood in reference to the like Phæ-
na of Mer- nomena of *Mercury*; only it must be
cury considered, that the *Orbit* of *Mercury*
being lesser than that of *Venus*, hence
Mercury never appears at such a Di-
stance from the Sun, being never a
whole Sign distant from it, and so
very seldom to be seen. In like
manner, *Mercury* going round its *Or-*
bit in shorter Time than *Venus* does
her *Orbit*; hence the direct Motions,
Stations, and Retrogradations of *Mer-*
cury will occur oftner, than those of
Venus. And so much may suffice
for the two inferiour primary Pla-
nets.

7. As the Agreement between the
The A- Phænomena of *Venus* and *Mercury* ar-
greement rises from their being both inferiour
between Planets

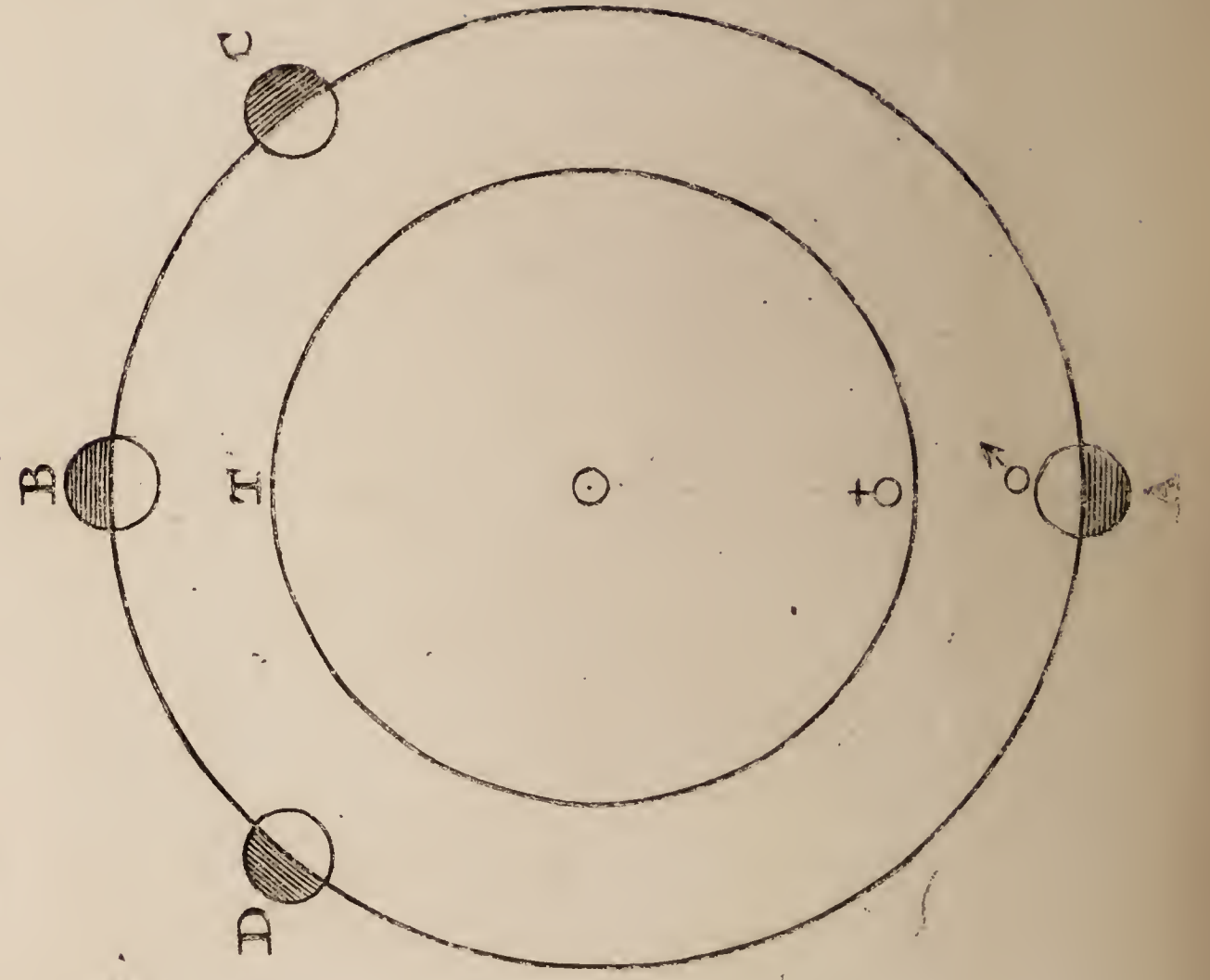


Fig. 23.



Pag. 80.

Fig. 24.



of Venus and Mercury.

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Planets to the Earth; so a like Agreement between the *Phænomena* of *Mars*, *Jupiter* and *Saturn*, arises from their being superiour Planets to the Earth.

*the Phæ-
nomena of
the supe-
riour Pla-
nets, arises
from such
their Si-
tuation.*

Let then in *Fig. 23*, T & represent the *Orbit* of the Earth, M & the *Orbit* of (any superiour Planet, particularly) *Mars*. 'Tis evident, that *Mars* will not appear to us always accompanying the Sun, (as do the inferior Planets, *Venus* and *Mercury*), but will appear sometimes as diametrically opposite to the Sun. For whereas the Earth goes round its *Orbit* sooner, than *Mars* does his; 'tis obvious that the Earth will sometimes be in the Middle between *Mars* and the Sun; for Instance, while *Mars* is at M, the Earth may be at A.

8.
*The superi-
our Pla-
net Mars
appears
sometimes
Diametri-
cally op-
posite to
the Sun.*

Further, supposing *Mars* to be in M, and the Earth to be in B, *Mars* will appear stationary, for the Reason assigned, *Sect. 3*, concerning the like *Phænomenon* of *Venus*. As the Earth moves from B through C, D, E, F, G to H, *Mars* will appear to move forward among the fixed Stars; but with this Difference, that he will appear

9.
*The superi-
our Planet
Mars, why
appears
sometimes
to stand
still, some-
times to
move for-
ward,
sometimes
backwards*

appear to move quicker, when he is most remote from the Earth, and in Conjunction with the Sun, (*i. e.* when he and the Earth are so situated, as is represented *Fig. 23*, by supposing the Earth to be in D E F, and *Mars* in or about M,) and slower, when he is so situated with Respect to the Earth, as M is represented *Fig. 23*, to be situated with Respect to either of the two Segments of the Earth's Orbit, B C or G H. Whenever the Earth has such a Situation to *Mars*, as H hath to M in *Fig. 23*, (which will at Length be, forasmuch, as although *Mars* moves the mean Time round the Sun, the same Way as the Earth, or according to the Series of the Signs ; yet the Earth moves faster, and so will overtake *Mars*,) the Planet *Mars* will again appear to stand still. And some short Time after will appear to go backward, or contrary to the Series of the Signs. For the Earth, as it moves from H thro' A to B, having overtook and gone beyond *Mars*, will make *Mars* appear to us to move contrary to the Series of the Signs, or from ☿ towards ♀, &c. And in this Situation *Mars* ap-

pears

of Mars, Jupiter. and Saturn. 79

pears opposite to the Sun, and also greatest, because it is then nearest to the Earth.

The like *Phænomena* happen to **10.**
Jupiter and *Saturn*, save that the Re- Jupiter
and Saturn
have the
like fore-
mentioned
Phænomena
with
Mars.
 trogradations of *Saturn* are more fre-
 quent than those of *Jupiter*, and of
Jupiter than those of *Mars*; foras-
 much as the Earth does oftner over-
 take *Saturn* than *Jupiter*, and *Jupiter*
 than *Mars*.

'Tis obvious, that the *Orbit* of the **11.**
 Earth being nearer the Sun than the None of the
superiour
Planets
can hide
the Sun,
but any of
them may
be hid by
the Sun.
Orbits of the Superiour Planets, none
 of these can hide the Sun from the
 Earth. But on the contrary, any of
 them may be hid by the Sun, while
 the said Planet is direct, if it be but
 near enough to a Node.

Lastly. *Saturn* and *Jupiter* appear **12.**
 not to us with several Phases, but Saturn and
Jupiter,
why appear
always
with a full
Orb.
 always with a full Orb; forasmuch
 as that Hemisphere of each, which is
 toward the Sun, and so enlightened,
 is also always toward the Earth, the
 Earth being (comparatively) never far
 distant from the Sun, which is the
 Center of the *Orbits* of *Jupiter* and
Saturn. For the Distance of *Jupiter*
 from the Sun is above five Times.
 and

and that of *Saturn* almost ten Times, greater than that of the Earth from the Sun.

13. But it is not so as to *Mars*. For Mars, why the Distance of *Mars* from the Sun not appears so likewise. being but (*) half as much again as the Distance of the Earth from the Sun, it follows that the Hemisphere of *Mars*, which is towards the Sun, will not always (so much as sensibly appear to) be toward the Earth. In Fig. 24, let T be the Place of the Earth in its Orbit T δ , and the Circle A B C D denote the Orbit of *Mars*. 'Tis evident, that *Mars* being in A or B, (that is, either in Conjunction with, or in Opposition to the Sun,) turns the same Face towards the Earth, as it does towards the Sun, and so shines with a full Orb. But in C or D the enlightened Face or Hemisphere of *Mars* is not all seen; but *Mars* appears a little defective of Light, in that Part of it which is from the Sun, and so appears gibbous. And thus we have solved at least the more remarkable *Phænomena*;

(*) That is, as 15. to 10.

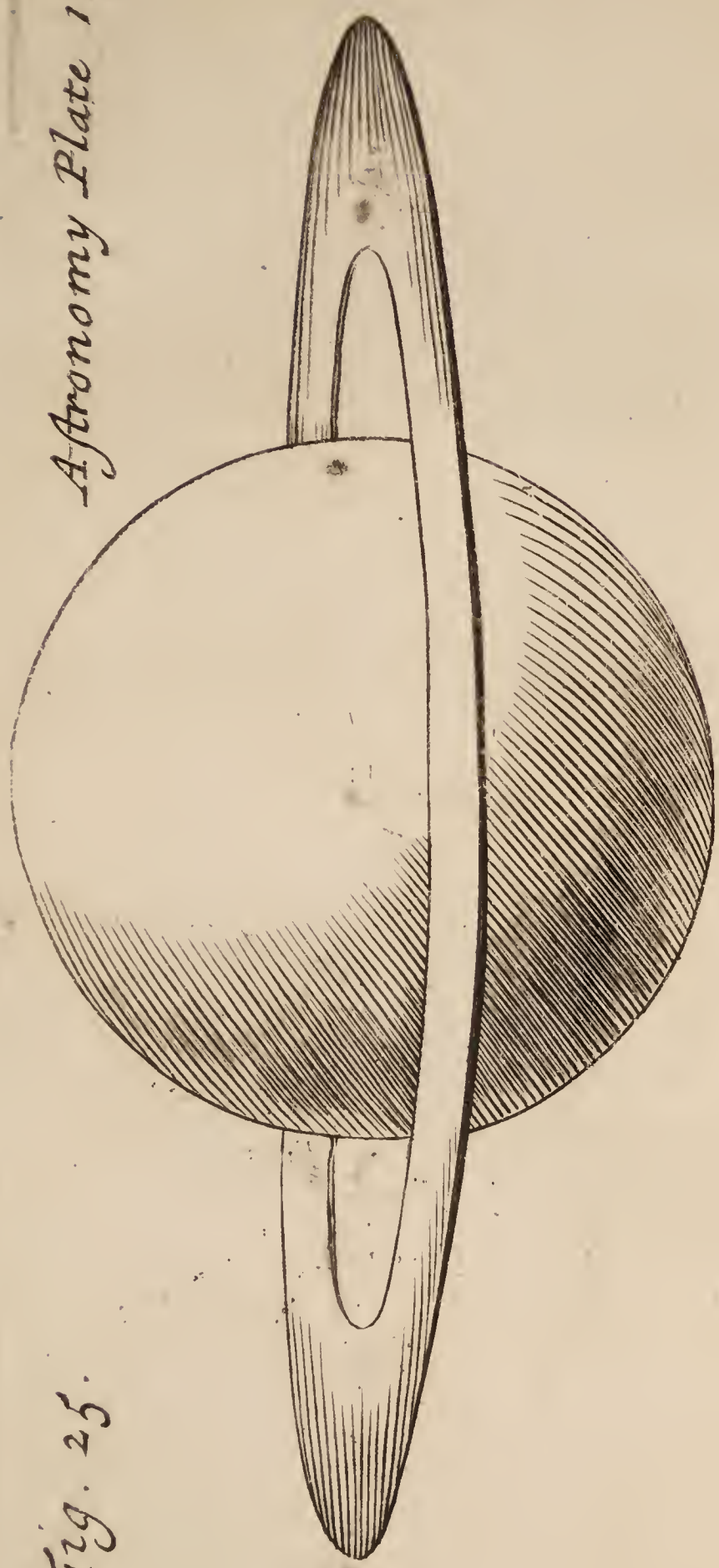


Fig. 25.

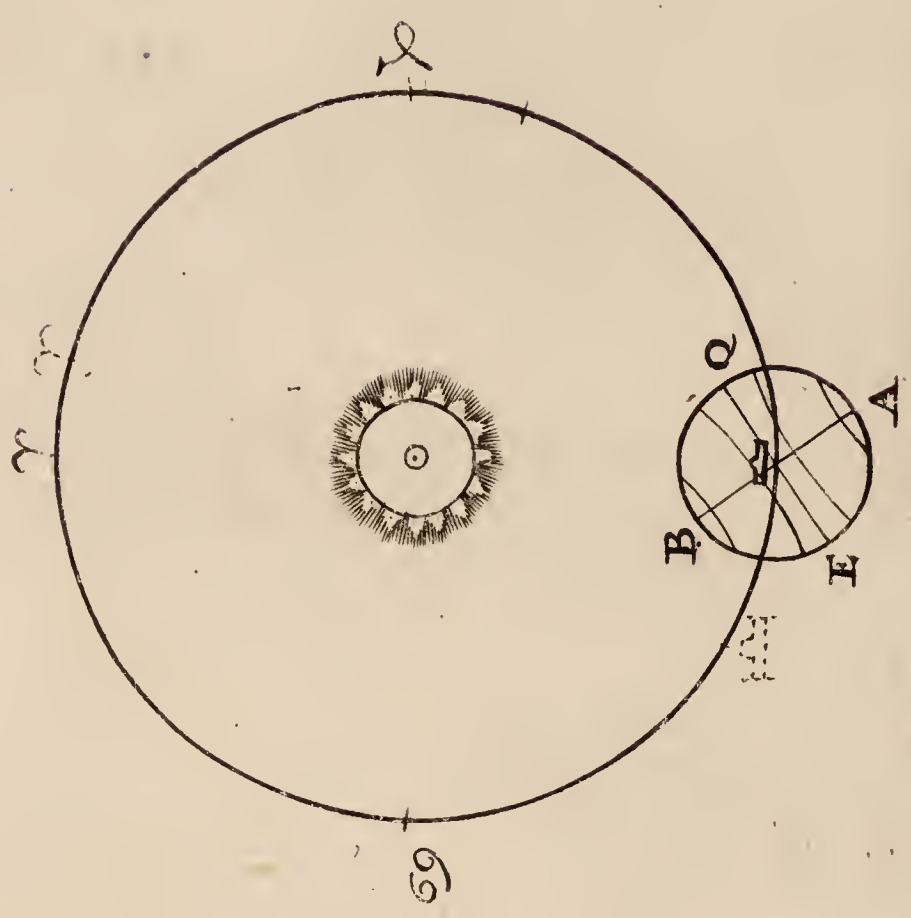


Fig. 26.

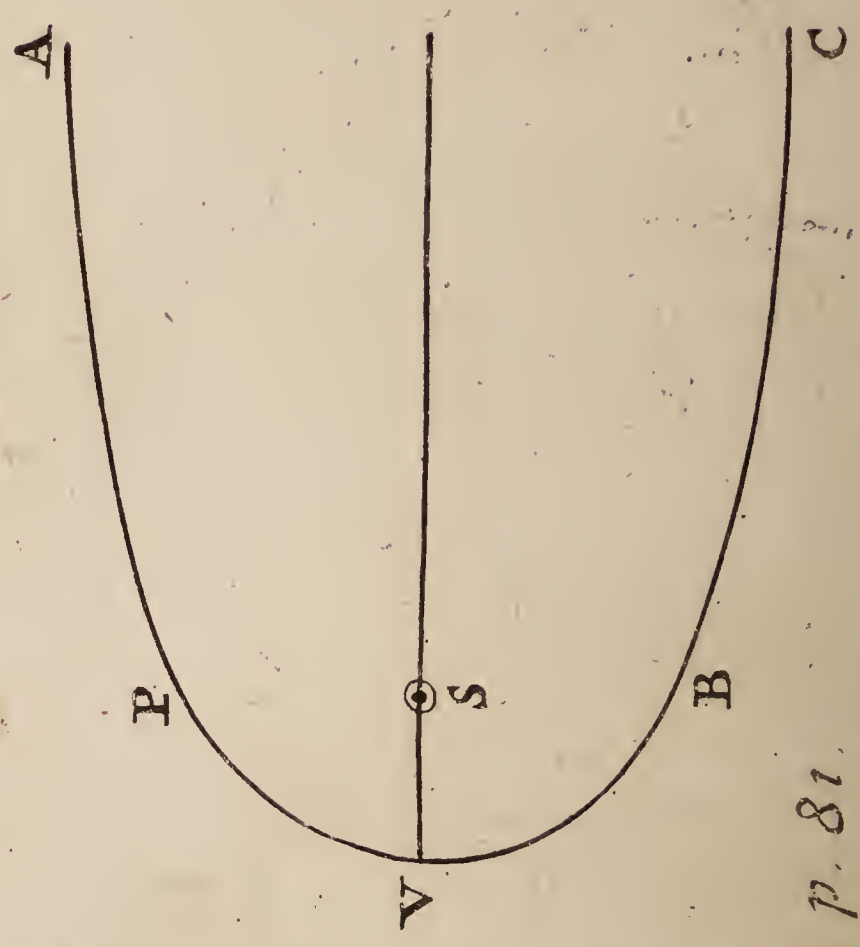


Fig. 27.

Place this facing p. 81.

both of the inferiour and superiour primary Planets.

It remains only to add somewhat 14.
concerning the *secondary* Planets, be- The Sate^ls
lites of Ju-
piter and
Saturn un-
dergo Ec-
lipfes, &c.
sides what has been said of them,
Chap. 1. And the first Particular that
deserves Observation, is this, that the
like *Phænomena* to those which hap-
pen between the Earth and the Moon,
happen between *Jupiter* and *Saturn*,
and their respective *Satellites*; foras-
much as the said *Satellites* are no
other than so many Moons in respect
to their respective primary Planet.
Hence, whenever either primary Pla-
net so comes between the Sun, and
any one of its respective *Satellites*, as
to hinder the Rays of the Sun from
falling upon it, it suffers an Eclipse.
And on the other hand, whenever
any *Satelles* comes so between the Sun
and its primary Planet, as to inter-
cept the Sun's Rays from its Primary,
the said Primary undergoes an Ec-
lipse.

The second Particular worthy of 15.
Observation is the *Phænomenon* of Sa- Of the An-
nulus or
Ansæ of
Saturn.
turn, which appears like an *Annulus*
or Ring, encompassing *Saturn*, as is
represented *Fig. 25.* From the vari-
ous

ous Position of this *Annulus* in respect of the Sun and the Observer, (it being opacous, like *Saturn* it self,) arises the several Phases of (what they call) the *Anse* of *Saturn*, because they appear like the two Handles of a Cup, or the like. And this is sufficient to our present Design, concerning the inferiour and superiour Planets, as also concerning the *Satellites* of *Jupiter* and *Saturn*.



C H A P. VII.

Of the Phænomena of the fixed Stars.

HAVING shewn how the *Phænomena* of the Sun, and Moon, and planetary Stars may be solved, we are to proceed next to the Solution of the *Phænomena* of the *fixed Stars*. And these, not borrowing their Light from the Sun, but shining with their own native Light, are therefore not subject to any such Deficiency of Light, as is called an Eclipse.

It is indeed observed of (*) some of the fixed Stars, that they do for a certain Period appear, and then disappear. Which *Phænomena* is supposed to arise from the said Stars having some *Maculæ* or Spots, which move round them in certain *Periodical* Times; as the Spots of our Sun are observed to move round it. Nay,

(*) Concerning such fixed Stars, see Dr. Gregory's *Astron. Phys. and Geom. Elem. Lib. 2, Prop. 30.*

it is thought, that these Spots do sometimes grow so great, as to quite cover the Star to which they belong, and so to make it disappear altogether; and that this is the Reason, that several fixed Stars observed by the Ancients, are now not to be seen. And this Opinion is countenanced by the Observations that have been made, that sometimes a whole Year together our Sun has shone with a more faint Light than at other Times; this being supposed to be caused by the Spots of our Sun being for that Time grown greater than Ordinary.

3.
 of the different Magnitude of the fixed Stars.
 As to the fixed Stars appearing of different *Magnitudes* or Bigness to us, this is ascribed vulgarly to their being really some bigger than others. But the more learned in *Astronomy* refer this apparent Difference of Magnitude only to their different Distances from us. As this Difference of Distance is sufficient to make some appear bigger, some lesser; so the Distance of the nearest to us being vastly great, hence our Sense of Vision cannot discern the different Distances, and consequently they appear to us as all placed in one and the same

same concave Sphere. By Reason of their apparent different Magnitudes, they are usually distinguished into six Classes, being respectively called Stars of the *First, Second, &c. Magnitude*.

As to the Rising, Setting, and Revolution of the fixed Stars round the Earth once in 24 Hours, it has been above observed, that these *Phænomena* may be solved by the diurnal Revolution of the Earth round its own *Axis*. But besides this apparent diurnal Motion, from East to West, the fixed Stars seem to have another Motion, whereby they seem to move very slowly from West to East, or according to the Series of the Signs. This Motion is so very slow, that it is computed to require about 25 or 26 thousand Years for the fixed Stars to seem carried thereby round the Heavens; whence it is stiled (†) *Annus Magnus*, or the great Year.

4.
The seem-
ing proper
Motion of
the fixed
Stars very
slow.

(†) It is also stiled *Annus Platonius*, because the Platonists teach, that every such Period Things are restored to the same State and Condition, as they were so many Years afore.

5. This Motion is commonly esteemed as the real proper Motion of the fixed Stars. But the more learned in *Astronomy* conceive the fixed Stars to have no such real Motion, as for other Reasons, so particularly for this, *viz.* because the said Motion of all the fixed Stars may be more simply, and compendiously solved, by the bare changing of the Places of the *Equinoctial* Points. For it comes to the same, whether we suppose the *Equinoctial* Points to be unmovable, and the fixed Stars to move forward according to the Series of the Signs; or the fixed Stars to be unmoveable, and the *Equinoctial* Points to be moved backward, or contrary to the Series of the Signs. What has been said, is illustrated, *Fig. 26*, where γ $\odot$ $\simeq$ ω represent the *Orbit* of the Earth about the Sun, A E B Q the Earth it self, γ and $\simeq$ the two *Equinoctial* Points for any one Year. The Earth moving forward again from $\simeq$ through ω towards γ , the Plane of the Terrestrial *Equator* being produced, will pass through the Sun * at [γ ,]

* Note, That these [γ] [$\simeq$] stand for the prick'd γ and $\simeq$ in the Figure, the Types of which could not be had in Time.

before that the Center of the Earth comes to γ . And in like manner, the Earth moving forward from γ through ∞ to ∞ , the Plane of her *Equator* being produced, will pass through the Sun at $[\infty]$, before that the Center of the Earth comes to ∞ . But the *Equinox* will be then, when the Sun is found in the Plane of the Terrestrial *Equator*; and those Points of the *Ecliptick* are rightly esteemed the *Equinoctial* Points, wherein the Sun is seen at the two *Equinoxes*. Whereas, therefore, γ and ∞ were the *Equinoctial* Points the last Year, the next Year $[\gamma]$ and $[\infty]$ will be the *Equinoctial* Points; and so the *Equinoctial* Points will go backwards, considered as to several Years. And by this Change of the *Equinoctial* Points, a fixed Star that keeps its Place at that Point of the *Ecliptick*, which is denoted by γ , and where afore was the vernal *Equinoctial* Point, will now seem to be moved forward from the vernal *Equinoctia* Point to $[\gamma]$ as much as the interval γ $[\gamma.]$ Wherefore, this being the most Simple, and consequently most natural Way of solving the *Phænomenon* we are speaking of, it is generally embraced now a-days.

And not only so, but it is also (||) mathematically demonstrated, for what Reasons the *Equinoctial* Points do thus move backward, or the *Equator* every Year crosses the *Ecliptick* a little sooner or forwader than it did the last Year. Whence that which is commonly called the *proper Motion of the fixed Stars*, is now a-days stiled by the learned in *Astronomy*, the *Præcession* or *Anticipation of the Equinoctial Points*.

6. It remains only to set down the Constellations, whereto the more remarkable of the fixed Stars are reduced. It has been shewn already, what are the twelve Constellations or Signs, whereby are comprehended the fixed Stars that lie in the *Zodiack*. In respect of which, the other Constellations are distinguished into northern or southern. The northern Constellations first distinguished by the Antients, are the *little Bear*, the *great Bear*, (or *Charles-wain*,) the *Dragon*, *Cepheus*, *Bootes*, the *northern Crown*, *Hercules*, the *Harp*, (or, as it is stiled

The several Constellations, to which the more remarkable fixed Stars are reduced.

(||) See Dr. Gregory's *Astron. Lib. 1. Prop. 64.*

by some, the *Vultur cadens*,) the *Swan*, *Cassiopeia*, *Perseus*, *Andromeda*, the northern *Triangle*, the *Charioteer*, the great *Horse* or *Pegasus*, the little *Horse*, the *Dolphin*, the *Arrow*, the *Eagle*, *Serpentarius*, the *Serpent*. To these 21 northern Constellations were afterwards added the Constellations of *Antinous*, *Berenice's Hair*, and (by us English) *Charles's Heart*. The southern Constellations known to the Antients are the *Whale*, *Eridanus*, the *Hare*, *Orion*, the greater *Dog*, the lesser *Dog*, the *Ship*, the *Hydra*, the *Crater* or two-handed-Pot, the *Raven* or *Crow*, the *Centaur*, the *Wolf*, the *Altar*, the southern *Crown*, the southern *Fish*. To these 15 are not long since added 12 Constellations, made up of the fixed Stars about the south Pole, and not visible to us, viz. the *Phoenix*, the *Crane*, the *Indian*, the *Peacock*, the *Apus*, the southern *Triangle*, the *Fly*, the *Chameleon*, the flying *Fish*, the *Toucan* or *American Goose*, the *Hydrus*, the *Dorado*, and the *Royal Oak*.

Besides these Constellations there appears in the Heavens a certain Tract, which goes quite round the Heavens, ^{7.} of the ^{milky} Way.

Heavens, and from its appearing to be of a milky Whiteness, is called *Via (*) Lactea*, or the *milky Way*. It is now, by the Help of Telescopes, discovered to be no other than an innumerable Multitude of little fixed Stars.

8.
Of the fixed Stars,
called *Informes*.

Such fixed Stars as belong not to this Milky Way, nor to any of the Constellations, are called *Informes*, as not being yet reduced to any *Form* or *Image*, as the Constellations are. And so much for the fixed Stars.

(*) It is for the like Reason called *Galaxia* by the *Greeks*.

C H A P. VIII.

Of the Phænomena of Comets.

T Here remains now only the *Phæ-* 1.
nomena of *Comets* to be solved, Comets,
 which are spoken of last, because why treat-
 there are not yet such Discoveries ed of in the
 made, as afford the like Degree of last Place.
 Certainty in the Solution of the *Phæ-*
nomena of *Comets*, as there is in sol-
 ving the *Phænomena* of the other Ce-
 lestial Lights; as also because it is
 not known yet, whether *Comets* be-
 long only to this our Solar System,
 or whether they may not also pass
 into other of the Mundane Systems,
 which have the fixed Stars for their
 several respective Suns.

It is supposed most probable by 2.
 the Learned in *Astronomy*, that they Comets
 move in some conick Section, which supposed to
 has the Sun in one of its Focus's. For move in
 this Sort of *Orbit* is found best to some co-
 agree to the Observations that have nick Secti-
 been made concerning the Motion of on.
Comets. Some indeed have formerly
 thought,

thought, that they move in right Lines; and some Calculations that have been made concerning their Motion, have agreed well enough to this Hypothesis. But then it is to be noted, that this will hold the same, although Comets move in a conick Section, if so be the Observations be made in that Part of their *Orbits*, which comes very near to a right Line. Let A P V B C in *Fig. 27*, be a conick Section very eccentric, and let one of its Focus's be S the Center of the Sun. It may be, that the Comet may be observed, whilst it is moving along the Part A P of its *Orbit*; and the rest of the Time, whilst it moves from P through V B to C, it may be hid from us by the Rays of the Sun. Or the Comet may be so hid from us, whilst it moves along A P V B, and may be then observed, when 'tis come to B, as it is about to describe the Line B C. And in both these Cases, the Line described by the Comet will not be sensibly different from a Right. Moreover, the Comet being observed in A P his Descent towards the Sun, and then drawing daily nearer to the Sun,
and

and after that lying hid for some Time under the Sun's Rays, and at Length getting again out of the Sun's Rays on the other Side of the Sun; hence it comes to pass, that one and the same Comet is looked upon to be two different Ones, which both move only in right Lines, *viz.* one in A P, the other in B C. Whereas in reality it may be all the while one and the same Comet, whose Trajectory (or Line, which it describes by its Motion) if considered together, both as to its Descent toward the Sun, and also as to its Ascent from the Sun, will hence be found to be no other than a conick Section, as was afore laid down.

Of the three conick Sections, the *Ellipsis* is found most agreeable to the ^{3.} *Comets* Motions (as of the Planets, so also) ^{supposed to move in} of Comets. And it can be no other, ^{that conick} if Comets be Bodies of a lasting Sub- ^{Section,} stance as are the Planets, and like ^{which is called an} these have a Periodical Motion round ^{Ellipsis.} the Sun. If Comets have not such a Periodical Motion, then their Trajectory is Parabolical, or Hyperbolical.

Some

4. Some Comets move like the Planets, from West to East; some from East to West; others from North to South, and others lastly from South to North. And their *Orbits* as to Greatness, Situation, and Inclination, as well in Respect to one another, as to the *Orbits* of the Planets, are various and different.

The various Motions, &c. of Comets.

5. Lastly, A Comet does visibly consist of two Parts, one called the *Head*, the other called the *Tail*. The Head is the Solid Body of the Comet, and is opacous, as appears from the Shadow it casts. The Tail is conceived by the Learned to be no other than a thin Vapour arising from the Head by Heat. Namely, whilst the Comet is descending to its *Perihelium*, those Vapours which had afore settled on it, when it was in the Regions remotest from the Sun, being now rarefied by the Heat of the Sun do ascend, *i. e.* fly off that Way which is from the Sun. Hence it comes to pass, that the Tail of a Comet grows greater and greater, as the Comet approaches nearer and nearer to its *Perihelium*; and on the other hand, the Tail grows less and less, as the Comet

Comets consist of two Parts, an Head and Tail.

Comet goes further and further from the Sun ; and consequently the Tail is greatest and most shining, presently after the Comet has been most heated in its *Perihelium*. And thus it has been shewn, how the more remarkable *Phænomena* of the Celestial Bodies may be solved or explained according to the *Copernican Hypothesis*.



C H A P. IX.

*A Description of the Celestial
(and also Terrestrial Globe.)*

1. *The Celestial Phænomena are represented by artificial Machines, the chief whereof is the Globe or Sphere.* **I**N the foregoing Chapters, the Celestial *Phænomena* have been treated of, as considered *in themselves*. I proceed now to treat of them, as they are represented by *artificial Instruments and Machines*, among which the chief is the *Sphere or Globe*.

2. *The import of the Words, Sphere and Globe.* The Word *Sphere* we borrow from the *Greek Language*, as we do the Word *Globe* from the *Latin*; each Word, in its respective Language, answering one to the other, and denoting a round Body, that is, according to the *Mathematical Definition* thereof, a Body from whose inmost Point, called its *Center*, all right Lines drawn to its Surface are equal one to the other. But the Word *Sphere* is now a-days commonly used to denote a Machine somewhat different from a *Globe*, and more peculiarly

cularly stiled an *Armillary Sphere*; forasmuch as it does not consist of a round continued Surface, but only of some Circles duly placed together, and fancied to resemble *Armilla*, i. e. Bracelets.

The Sphere and Globe are made to represent principally such *Phænomena*, as arise from the Diurnal Motion. Whence that Part of *Astronomy*, which treats of the diurnal Motion, is frequently stiled (*) *Spherical Astronomy*, or the *Doctrine of the Sphere*. In like manner, the other Part of *Astronomy*, which treats of the annual and proper Motion, is stiled *Theoretical Astronomy*, from the Schemes or (as it is said) little Paper Machines, formerly made to illustrate the (†) Theory of the said proper Motion, and thence called *Theoria*.

There are Spheres made agreeable to the *Copernican Hypothesis*, and others made agreeable to the vulgar

(*) This makes the first Part in common Astronomical Treatises; and Theoretical Astronomy the second Part.

(†) It is originally a Greek Word, denoting Speculation or Contemplation.

or *Ptolemaick* Hypothesis. But the former Sort being very costly, and the latter Sort being not of so general Use (even in their own Way, or according to the *Ptolemaick* Hypothesis) as the Artificial Celestial Globe, hence this is most commonly made use of to illustrate to young Students the Celestial *Phænomena*. And when they have been once set right as to the true System of the World, and the true Causes of the said *Phænomena*, by having had the *Copernican* Hypothesis explained to them; then it is allowable for them to make Use of the common Celestial Globe, though it represents the Celestial *Phænomena*, not according to their *real Nature*, but only according to their *Appearances*: Forasmuch as it is convenient, not to say necessary, in common Discourse to talk of the celestial *Phænomena* according to the common Notions of them, *i. e.* according to their Appearance to our Senses, from which the Vulgar derive their Notions.

5. On these Considerations, having in
On Account the eight foregoing Chapters of this
of such its Treatise explained the real Nature
Usefulness, and Causes of the Celestial *Phænome-*
the Cele-

Of the Celestial Globe, &c. 99

na, I shall in the remaining Part of ^{stial Globe} this Treatise shew, how the said ^{is here} *Phænomena* are represented by the ^{treated of} Celestial Globe, as to their Appea- ^{and descri-} rance to our Sense. And therefore I ^{bed.} shall first (in this Chapter) describe the artificial Celestial Globe, and then (in the following Chapter) shew the Use thereof.

Among the several Circles belong- 6. ing to the celestial Globe, I shall be- ^{Of the Ho-} gin with the *Horizon*; forasmuch as ^{rizon of} the artificial *Horizon* is the outermost ^{the Cele-} Circle of the artificial Globe, and ^{stial Globe.} that which encloses and upholds all the rest of the said Globe.

It has been (||) afore observed in 7. short that the *Horizon* is so called, ^{The Hori-} as being that Circle which bounds ^{zon two-} the Sight. To which it is further to ^{fold, Sen-} be added here, that the *Horizon* is ^{sible and} distinguished by *Astronomers* into the ^{Rational.} *sensible* and the *rational Horizon*.

For a right and clear Apprehension 8. of the sensible *Horizon*; it must be cal- ^{The sensi-} led to Mind, that the Sight, if not hin- ^{ble Hori-} dered, extends it self equally every Way. ^{zon, what,} ^{and why so} ^{called.}

Hence (†) it comes to pass, that, when we stand upon the Surface of the Earth, and the Eye has a free View all round, so much of the Heavens as is seen, appears to us under the Figure of a concave Spherical Surface, reaching to the Surface of the Earth. The seeming Interfection or Meeting of the Surface of the Earth with the fore-mentioned concave spherical Surface of the Heavens, being continued every Way round the Eye, represents a Circle, which is called (by a Greek Word) the *Horizon*, because it bounds the Sight, and divides the seen Part of the Heavens from the unseen; and it is particularly stiled the *sensible Horizon*, because it does thus actually fall under our Sense of Vision, when the Eye has a (*) free View.

9. The rational *Horizon* is so called, because it falls not under our Sense of Vision, but is only to be conceived by our Reason. For hereby is denoted that *Horizon*, which would bound the Sight supposing the Earth bisect-

The rational *Horizon*, what, and why so called.

(†) See this illustrated *Fig. 1.* of my *Opticks*.

(*) Hence it is observable, that every *Horizon* that actually bounds the Sight is not properly the *sensible Horizon*.

ed, and one Half of it removed, and the Spectator placed on the Center of the Earth. What has been said of each *Horizon*, is illustrated *Fig. 28*, where the greater Circle denotes the Heavens, the little Circle, the Earth, the Line drawn through P, the sensible *Horizon*, the other Line the Rational. Whence it is also evident, that the sensible *Horizon*, and its respective rational *Horizon*, are always parallel one to the other, and that their mutual Distance is the Semi-diameter of the Earth.

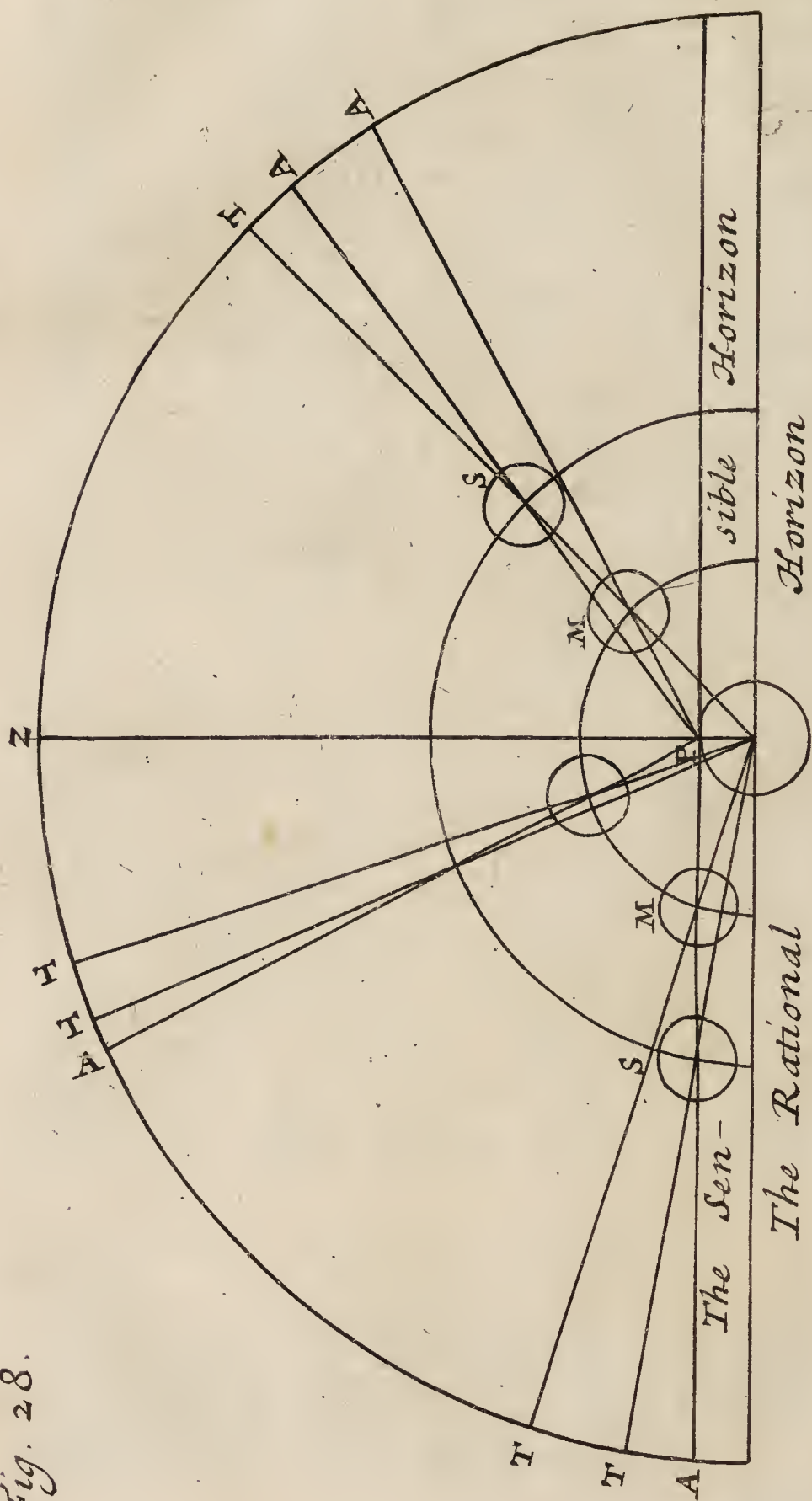
Now the whole Earth being but *as* 10. *The Earth but as a Point in respect of the Sphere of the fixed Stars.* a Point in respect of that vastly Distant Sphere, wherein the fixed Stars seem to be all placed; hence the Distance between the rational and sensible *Horizon*, being no more than the Semi-diameter of the Earth, makes no sensible or considerable Difference as to the *Phænomena* of the fixed Stars.

But the Distance between the rational and sensible *Horizon*, bears a considerable Proportion to the Distance of the other celestial Lights from the Earth, and consequently makes 11 *Of the parallax of the Celestial Lights.* a con-

a considerable Difference as to the (†) Places of these other celestial Lights, which are between the Earth and the fixed Stars. This is also illustrated *Fig. 28*, where the outermost Semicircle represents Half the Sphere of the fixed Stars; the other two Semi-circles represent the Halves of the *Orbits* of any two celestial Lights between the Earth and the fixed Stars; and the little Circle about the common Center of the fore-mentioned Semicircles represents the Earth. The Lines drawn from P (the Place of the Spectator) on the Surface of the Earth, through the Centers of the Celestial Lights M and S, to the Sphere of the fixed Stars, do there denote the *apparent* Places of the said celestial Lights; and the other Lines drawn from the Center of the Earth, through the Centers of M and S, to the Sphere of the fixed Stars, do there denote (what are cal-

(†) Here must be remembered what is said, *Chap. I. Sect. 15.* viz. That that Point or Part of the Sphere of the fixed Stars, between which and the Spectator any other of the Celestial Lights appears to be, is counted the *Place* of the said Celestial Light.

Fig. 28.



led) the *true* Places of M and S. Whence may be learned, the Reason of thus taking Notice of the Rational *Horizon*, forasmuch as *that* is esteemed by *Astronomers*, the *true* Place of a *Phænomenon*, (where it would be seen to a Spectator placed on the Center of the Earth, *i. e.* where) it is with Respect to the rational *Horizon*. Thus T is the true Place of M and S, A the apparent Place of each. The Difference between the true and apparent Place (which are always in the same vertical Circle) of any celestial Light or *Phænomenon*, is called its (||) *Parallax*.

Having

(||) It is a *Greek* Word signifying a *Variation* or *Difference*. It seeming too long a Digression to insert into the Body of this Chapter an Explication of the *Parallax*, and on the other hand the *Parallax* seeming a Particular too material to be only mentioned, I judged it best to adjoin here by way of Note, what seems requisite to be said of it. The *Parallax* then may be considered, either with Respect to different celestial Lights, or the same. In the former Respect, the *Parallax* is greater or lesser, as the Celestial Lights are less or more distant from the Earth. Thus Fig. 28, the *Parallax* T A of M, is greater than the *Parallax* T A of S. And hence the Moon has the greatest *Parallax*, as being nearest of all the Celestial

H 4 Lights

12. Having shewn the Difference between the sensible and rational *Horizon*, and withal taken Notice, that it is the *rational Horizon*, which is principally regarded by *Astronomers*, it is next to be observed, that accordingly it is the *rational Horizon*, which is principally

The Horizon of the Globe represents principally the rational Horizon.

Lights to the Earth. In respect of the same Celestial Light, its greatest *Parallax* is at the *Horizon*; and as the Celestial Light ascends higher and higher above the *Horizon*, so its *Parallax* continually decreases, till it quite ceases in the *Zenith* or Vertical Point. For there the two Lines which mark out the apparent and true Place, do fall in together, as is evident from *Fig. 28*. What more seems requisite to be here observed, is that the Angle made by the meeting of the two Lines just mentioned in the Center of the Celestial Light, is called the *Parallaical Angle*, or the *Angle of the Parallax*, and by it the *Parallax* is measured; as also that the apparent Place is always lower or nearer to the *Horizon*, than the true Place. Whence the *Parallax* has a quite contrary Effect to *Refraction*; forasmuch as this causes a *Phænomenon* to appear higher, or more above the *Horizon* than really it is. Thus in *Fig. 29*, let T denote the Earth, surrounded with the Atmosphere A E D; S some Star, and O the Spectator on the Surface of the Earth. Were there no Atmosphere, or were it of an equal Thickness with the *Æther*, the Rays of Light would come directly or in a right Line from S to O. But the Rays, when they have passed through the *Æther* S Q, entring at A into the Atmosphere, which is thicker than the *Æther*, hereby is refracted (*i. e.* as it were broken) and bent towards the right Line Q P, which is perpendicular to the Surface of the Atmosphere.

Fig. 29.

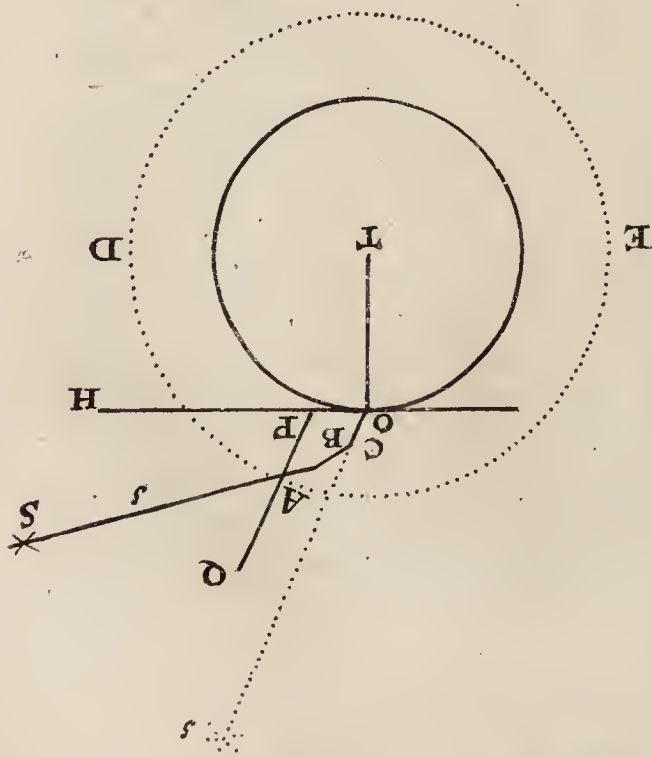
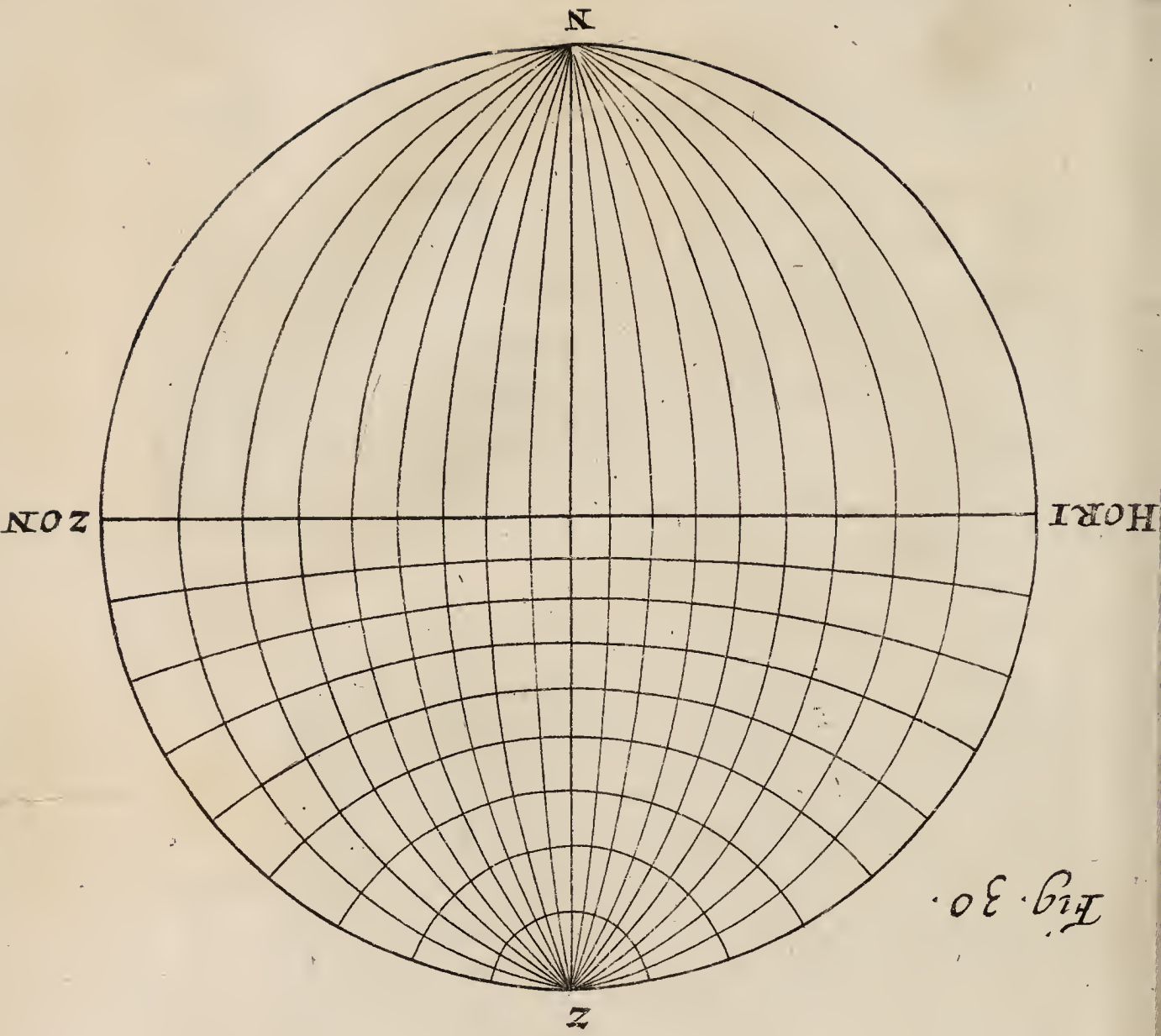


Fig. 30.



principally represented by the *artificial Horizon* of the Globe; which therefore is (or at least ought to be) so placed, as to divide the Globe it self exactly into two Hemispheres or equal Parts. But here it is to be re-

mosphere at A. And because it is likely, that the Atmosphere it self is not all along, from the *Æther* to the Earth, of an equal Thickness, but is thicker, as it is nearer to the Earth; hence a Ray coming from the Star S will be refracted, not only at A, but also at other Points within the Atmosphere, (as at B, C, &c.) and at each of these Points will be refracted the same Way, *viz.* toward T. But of the Ray A B C O, it is only the last Part C O, which affects the Eye; and therefore the Eye sees the Star at s, and consequently much higher, or much more above the *Horizon* O H, than really it is. But Refraction (as well as *Parallax*) is greater, when the *Phænomenon* is nearer to the *Horizon*; and as the *Phænomenon* ascends higher, it continually decreases, and quite ceases in the *Zenith*. To Refraction it is attributed, that the Sun and Moon appear of an Oval Figure near the *Horizon*. For the upper Rim of the Sun and Moon appearing a little higher, and the lower Rim a great deal higher than it really is, hence this will seem to be nearer to that than it really is; and so the erect or vertical Diameter of either Luminary will seem contracted, while the transverse or horizontal undergoes no such Contraction, forasmuch as its Extremities are alike elevated by Refraction. 'Tis also to the Refraction of the Sun's Rays to the Atmosphere, that the *Crepusculum* or *Twilight* is owing; for otherwise, as soon as the Sun is set, it would be presently quite Dark. By Refraction also the Sun and Moon appear above the *Horizon*, when their Bodies are somewhat under the *Horizon*.

marked,

marked, that although the whole broad wooden Circle, which encompasses the Rest of the Globe, may sometimes be called the *Horizon* of the Globe, yet properly and strictly it is only the inner Rim or Edge of the upper Surface of the said broad wooden Circle, that is the *Horizon* of the Globe, and (*) represents the true *Horizon*, whether Rational or Sensible.

13. For the Measuring of the Altitude of Almicantars, or Depression of any *Phænomenon*, the Zenith (i. e. its Distance above or below the *Horizon*,) they are conceived and Nadir. Circles to run parallel to the *Horizon* through every Point of the Globe; which (as is illustrated *Fig. 30*,) grow less and less on each Side of the *Horizon*, as they are more remote from it, and at length End in two Points. One of these Points being always

(*) The *Horizon* (as is above observed) is that Circle, i. e. that circular Line, wherein the Surface of the Heavens and the Surface of the Earth intersect, or are conceived to intersect, one the other. But a circular Line has only a circular Length, no Breadth, nor Thickness. And therefore it is properly the inner Edge of the upper surface of the broad wooden Circle, which is the artificial *Horizon* of the Globe.

over

over the Vertex, or Head of the Spectator, is therefore called the *vertical Point*, or by a single *Arabick Word*, the *Zenith*. The other Point, which is diametrically opposite to the former, is called by an *Arabick Word*, the *Nadir*. The *Zenith* is represented *Fig. 30*, by the Point Z, the *Nadir* by the Point N. The fore-mentioned parallel Circles between the *Horizon* and the *Zenith* or *Nadir*, are called from their Use, *Circles* or *Parallels of Altitude*, and by an *Arabick Word*, *Almicanters*.

For denoting what Point of the *Horizon* any *Phænomenon* is in, or is at least to be referred to, there are conceived also Circles crossing every Point of the *Horizon* at right Angles, and all crossing one another in the *Zenith* and *Nadir*. And from their common Interfection being thus in the *Zenith* or vertical Point, they are stiled *vertical Circles*, or by an *Arabick Word*, *Azimuths*. These are also illustrated *Fig. 30*.

Among the Points of the *Horizon* there are four, which are called the *Cardinal* (i. e. Principal) Points, and are distinguished by the Names of the *East*.

14.

Of Azimuth's or Vertical Circles.

15.

Of the four Cardinal Points of the Horizon.

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East, West, North, and South Points.
The east and west Points of every *Horizon* are those, wherein the Sun rises and sets, when he is in the *Equinoctial*. The other two are each 90 Degrees distant from the former, one towards the north Pole, and thence called the north Point; the other toward the south Pole, and thence called the south Point.

16. Among the vertical Circles, those two are of special Note, which pass through the Cardinal Points of the *Horizon*. That which passes through the east and west Points is called the *prime Vertical*; the other which passes through the north and south Points is stiled the *Meridian*, because every Day, when the Sun comes to that Circle, it is then *Meridies* or Mid-day within that *Horizon*. When any celestial Light is risen, it ascends still higher and higher, till it comes to the *Meridian*; and as soon as it has crossed that, it begins to descend lower and lower. Hence, when it is at the *Meridian*, it is said to *culminate*, (i. e. to be at its *Culmen* or Top-height for that Day,) and such
its

*Of the
prime
Vertical
and Meri-
dian.*

Of the Celestial Globe, &c. 109

its greatest Height is therefore called its *meridian Attitude*.

As the *Horizon* divides the World 17.
into an upper and lower (or visible The upper
and lower
eastern
and west-
ern Hemis-
spheres,
what. and invisible) Hemisphere; so the *Meridian* divides the World into an eastern and western Hemisphere; the former being so called, because it is that wherein the celestial Lights do rise; the other, because it is that wherein they set.

Though the whole brass Circle, 18.
which is immediately upheld by the *Horizon* at its north and south Points, The Meri-
dian of
the Globe,
what. be frequently called in gross the *Meridian of the Globe*; yet properly and strictly speaking, the artificial *Meridian* is only the graduated Edge of the said brass Circle.

The *Meridian* is the only vertical 19.
Circle, which is distinctly represented Of the
Quadrant
of Altitude. on the Globe. As for all the rest, they are represented in Part by the *Quadrant of Altitude* respectively applied to the Body of the Globe, from the *Zenith* to the *Horizon*. It is a long narrow Strip of Brass, made thin, that it might be pliant to the Body of the Globe; and made to reach from the *Zenith* to the *Horizon*,
so

so much of it as is contained between the *Zenith* and *Horizon*, being divided into 90 Degrees, as being just equal to the fourth Part of the Circumference of the Globe; whence it takes the Name of the *Quadrant*, being peculiarly stiled the Quadrant of *Altitude*, from its Use in taking the Altitude of any Point of the Globe. And as the Strip of Brass so called does by its Length from the *Zenith* to the *Horizon*, represent the fourth Part of a vertical Circle; so being rightly fastned on Top at the *Zenith*, and then moved round the Body of the Globe, by such its Motion, the several Points thereof will represent the several Almicanthars between the *Zenith* and *Horizon*.

20.
Of the
Axis, and
Poles of
the World,
in the
artificial
Globe.

Within the brass Circle called the *Meridian* of the Globe, hangs the Body of the Globe, being upheld by two Iron (as it were) Pins fastened to the *Meridian*, the Body of the Globe being made to turn round upon these two Pins, which therefore represent the *two Poles of the Equator*, or (as they are otherwise called) of the (†)

(†) They are so called, because all the World, but the Earth seems to turn round upon them.

World;

Of the Celestial Globe, &c. III

World; that by the little Bear on the Surface of the Globe, representing the Arctick or north Pole; and the other, the Antarctick or south Pole. The Piece of Iron passing through the Center of the Globe, and of which the two Iron Pins afore-mentioned are the Extremities, represents the *Axis of the World*.

From what has been above said, 21.
 (Chap. III. Sect. 5.) it is obvious, Of the E-
 that the *Equator* of the Celestial quator,
 Globe is the great Circle, drawn on Ecliptick,
 the Surface of the Globe in the very two Tro-
 Middle between the two Poles already picks, and
 mentioned; as also, that the great polar Cir-
 Circle, which crosses obliquely the cles of the
 said *Equator*, is the *Ecliptick* of the artificial
 Globe; and that the two lesser Cir- Globe.
 cles, which the said *Ecliptick* touches
 at its greatest Declination (northward
 or southward) from the *Equator*, are
 the two *Tropicks* of the Globe; that
 on the north Side of the *Equator*, the
Tropick of Cancer; that on the south
 Side, the *Tropick of Capricorn*; lastly,
 that the two lesser Circles drawn on
 the Surface of the Globe at the same
 Distance (*viz.* $23\frac{1}{2}$ Degrees) from
 each Pole of the *Equator*, as the *Tro-*
picks

112 *Of the Celestial Globe, &c.*

picks are from the *Equator* it self, are the *polar Circles* of the Globe; that about the *Arctick* or north Pole, the *Arctick Circle*; that about the *Antarctick* or south Pole, the *Antarctick Circle*.

22.
The Equator always
bifected
by the Ho-
rizon.

In reference to the *Equator*, it is here to be added, that whereas it has been afore in this Chapter, *Seet. 15*, observed, that the east and west Points of any *Horizon* are those, where the Sun rises and sets when he is in the *Equator*; and whereas also it is then equal Day and Night all over the World; it hence follows, that the artificial *Equator* in any due Position of the Globe, must cut the *Horizon* exactly in its east and west Points; and there cut it so, as to be equally divided by the *Horizon* into two Parts, one Half being above the *Horizon*, the other below. And by these Particulars it may be further proved, whether a Globe is truly made.

23.
The Positi-
on of the
Equator
to the Ho-
rizon
three-fold.

The Position of the *Equator* to the *Horizon*, is in general three-fold. For the *Equator* cuts the *Horizon*, either at *right* Angles, or at *oblique* Angles, or else it is *Parallel* to the *Horizon*.

Such

Of the Celestial Globe, &c. 113

Such as live under the celestial (or 24.
 which is the same, upon the ter-^{Of a right}
 restrial) *Equator*, their *Horizon* is ^{Sphere}
 crossed by the *Equator*, and conse-
 quently by all its Parellels at right
 Angles; and hence these are said to
 live in a *right Sphere*. The Property
 of which Sphere is this, that it is
 therein equal Day and Night through
 the whole Year. For the *Equator*
 and all its Parallels being bisected by
 the *Horizon* in a right Sphere, (as
 may be shewn by putting the mecha-
 nical Globe into such a Position, viz.
 so as that the *Equator* of the Globe
 may move round under the *Zenith*),
 and the Sun's diurnal Motion being
 always either in the *Equator*, or one
 of its Parallels; hence it follows, that
 the Sun (moving all the 24 Hours
 alike) must always make as long a
 Stay above, as below the *Horizon*,
 in a right Sphere; and consequently,
 that it must be there equal Day and
 Night through the whole Year.

Such as live on either Side the 25.
Equator, between it and its Poles, ^{Of an ob-}
 their *Horizons* do cross the *Equator*, ^{lique}
 and consequently its Parellels, at An- ^{Spheres}
 I gles

gles less or more oblique, according as they live less or more distant from the *Equator*. Hence these are said to live in an *oblique* Sphere, and their *Horizons*, though they all bisect or *equally* divide the *Equator* it self, yet do all less or more *unequally* divide its *Parallels*, according as the *Parallels* themselves, and the *Places* to which the *Horizons* respectively belong, are less or more distant from the *Equator*. Wherefore, the diurnal Motion of the Sun, when it is not in the *Equator*, being in some one of its *Parallels* thus less or more *unequally* divided by the respective *Horizons*, it thence comes to pass, that the Day and Night are less or more unequal at *the same time of the Year* (excepting the two *Equinoxes*) in *different Places*, according as the said *Places* are less or more distant from the *Equator*; and also that the Day and Night are less or more unequal at *different Times of the Year* in the same *Place*, according as the Sun is less or more Distant from the *Equator*. All which is evidently to be shewn upon the Globe.

Lastly,

Of the Celestial Globe, &c. 115

Lastly, Under the very Poles of 26. the *Equator*, or of the World, the *Horizon* and *Equator* run parallel one to the other, which Position is therefore called a *parallel Sphere*. The property of this Sphere is, that therein it is Day for Half the Year together, and Night for the other Half. For the *Equator* and *Horizon* being here Parallel, as long as the Sun stays on the same Side of the *Equator*, so long must it stay above the *Horizon* of that Pole, and consequently, so long together is it Day at the respective Pole, and Night at the opposite Pole. This is also evidently shewn upon the Globe, being placed so, as that its *Equator* and *Horizon* become parallel one to the other.

It remains to observe in reference 27. to the *Equator*, that a Revolution thereof is the Measure of a (||) *Nuchthemeron*, or the Space of 24 Hours. Accordingly, whilst any Point of the artificial *Equator* moves

The Revolution of the *Equator*, the Measure of a *Nuchthemeron*, or of 24 Hours.

(||) It is a Greek Word signifying the Space of one Day and Night taken together.

from the artificial *Meridian* round to the same Side of the said *Meridian* again; the Index, which is fastned to the north Pole of the Globe, will move quite round the Hour-circle fastened upon the *Meridian* about the said Pole. And by comparing the Motion of the *Equator* with that of the Hour-Index, it will sensibly appear, (if the Globe be made true) that as the whole Circumference of the Heavens, divided into 360 Parts, called Degrees, pass under the *Meridian* of any Place in a *Nuchthemeron* or 24 Hours; so 15 Degrees of the Circumference of the Heavens pass under the same *Meridian* every Hour. For according to the Rule of Proportion, as 24 Hours, are to 360 Degrees, so 1 Hour, is to 15 Degrees.

28.

The Zodiack, why divided into twelve Signs, and each Sign into thirty Degrees.

Proceed we next to observe in reference to the *Zodiack* or *Ecliptick*, that, the Reason, which induced the Old *Astronomers* to divide it into twelve Signs, is thought to be (*) prin-

(*) Some conceive the Reason to have been, because the Number *Twelve* has many aliquot Parts.

cipally this; viz. because the Moon goes twelve Times round the *Zodiack*, whilst the Sun goes once. And for the like Reason it seems to be, that, whereas one Revolution of the Sun round the *Zodiack*, is called the *Solar Year*, there are reckoned twelve Revolutions of the Moon round the *Zodiack* to make up the *Lunar Year*. Lastly, The Reason why each Sign of the *Zodiack* was distinguished into thirty Degrees, seems to be this, because the Moon always overtakes the Sun in (†) about thirty Days after she has left him.

And because the Sun *graditur*; i. e. 29. goes, in a Day and Night or 24 Degrees, Hour's Space, near upon one of these thirty Parts of a Sign; hence the said Parts are thought to be stiled by the *Latins*, *Gradus*, and so by us, *Degrees*. And from the Circle of the *Zodiack*, or more particularly of the *Ecliptick*, came this Name to be transferred to the like Divisions of all, not only astronomical, but also other mathematical Circles.

(†) See Chap. 4. Sect. 3.

30.
How to
find on the
Globe,
what Sign
answers to
each Ca-
lendar
Month.

Agreeably to the 12 Signs of the *Ecliptick*, the Solar Year is also divided into twelve Months, called *Solar Months*; each being the Space wherein the Sun goes through a Sign, and so containing almost $30\frac{1}{2}$ Days. How these Solar Months strictly so called, answer to the common Calendar Months, or (which amounts to the same) what Degree of the *Ecliptick* the Sun is in each Day of the 12 Calendar Months, is to be seen on the upper Surface of the broad wooden Circle of the Globe commonly called its *Horizon*; for thereon the 12 Signs of the *Ecliptick*, and the 12 Calendar Months are so placed, both according to the *Julian* and *Gregorian* Account, as that the Days of these may duly answer to the respective Degrees of those.

31.
The Divi-
sions of the
Zodiack
or Eclip-
tick are to
be known,
not by the
Constella-
tions or
Signs
them-

In reference to the 12 Divisions of the *Ecliptick* on the Surface of the Body of the Globe, it is to be observed, that neither the Constellations themselves, nor their Names, but their Characters shew, which Division of the *Ecliptick* is esteemed respectively to belong to each Sign, or goes

goes under the Name of each Sign. ^{selves, but}
 Thus the Character γ is placed at ^{by their}
 the Beginning of that Division, which ^{Chara-}
 is esteemed to belong to *Aries*; and
 the said Division of 30 Degrees be-
 tween γ and δ , is that which is de-
 noted by the Sign of *Aries*; whereas
 the Constellation so called, is now,
 great or most Part of it, out of that
 Division; and the Word *Aries* is
 affix'd to the said Constellation al-
 most at the End of the said Division.
 So the Division between π and ϕ , is
 that which is denoted by the Sign of
Gemini, though the Constellation so
 called, is almost entirely out of that
 Division, and consequently, the Word
Gemini affixed to the Constellation.

The Reason hereof is this. The 32.
 Constellations themselves (||) conti- ^{And the}
 nually (though very slowly) changing ^{Reason}
 their Situation in the *Zodiack* or *E-* ^{thereof.}
cliptick, in Conformity thereto, con-
 tinually to change the Names of the
 several Divisions, would create great

(||) To what this Change of Situation is owing
 really, is observed, *Chap. 7. Sect. 5.*

Confusion in *Astronomy*; forasmuch as it would make it an intricate Matter rightly to distinguish what Parts of the *Zodiack* belonged to the several Signs in different Ages of the World. Wherefore to avoid such Confusion, it has been with great Prudence judged Expedient, not to make any Change as to the Names of the Divisions, though the Constellations themselves do in Process of Time change their Places; but always to look on that which is esteemed the first Division of the *Zodiack* as belonging to *Aries*, at least to let it go always under the Name of *Aries*, (and so of the rest) though that Constellation it self (and so of the rest) have now so changed their Situation, as to be mostly, or in great Part out of the respective Division; and will in Process of Time be removed farther and farther from it.

33.
Of the
twelve o-
ther Cir-
cles of the
Globe, viz.

Besides the Circles hitherto mentioned, there are usually drawn on the Surface of the celestial Globe, twelve other Circles; six whereof cross perpendicularly the *Ecliptick* between its Signs, the other six cross perpendicu-
larly

larly the *Equator* at every like (*viz.* 30 Degrees) Distance, beginning to reckon from the first of *Aries*.

The six former are called **Circles of** 34.
Latitude, because that Arch of such a ^{The six} Circle, which is intercepted between ^{Circles of} any *Phænomenon* or Point of the Heavens and the *Ecliptick*, is the Measure of the said *Phænomenon*'s or Point's Latitude, *i. e.* Distance from the *Ecliptick* northward or southward. For the *Ecliptick* being the Circle in the Heavens of principal Regard, therefore, by it the Heavens are distinguished into two Hemispheres, one northern, the other southern.

By the same Circles is also measured the *Longitude* of any *Phænomenon* or Point in the Heavens. For by the Help of these Circles, any *Phænomenon* in the Heavens is referred to the *Ecliptick*, the said *Phænomenon* being understood to be in that Point of the *Ecliptick*, which is intersected by such a Circle passing through the said *Phænomenon*; and the Arch of the *Ecliptick* between the first of *Aries* and the said Point of Intersection, is the Measure of the said *Phænomenon*'s Longitude, 35.
^{Which are also Circles of}

122 *Of the Celestial Globe, &c.*

Longitude, or Distance from the first of *Aries* reckoned according to the Series of the Signs.

36. By the six other Circles, any *Phænomenon* or Point in the Heavens is referred in like Manner to the *Equator*; and they are called Circles of *Declination*, because that Arch of such a Circle, which is intercepted between the said *Phænomenon* and *Equator*, is the Measure of its Declination, *i. e.* of its Distance from the *Equator*, northward or southward. Among these Circles, the two of chief Note are the two (*) *Colures*; one whereof crosses the two *Equinoctial* Points, and is therefore called the *Equinoctial Colure*; the other crosses the two *Solstitial* Points, and is therefore called the *Solstitial Colure*.

37. And thus we have described the several Circles, and more remarkable Points of the celestial Globe. It remains to observe, that of all the fore-mentioned Circles, these are usually

The principal Circles of the Globe, usually reckoned Ten, and distinguished into six greater, and four lesser Circles.

(*) The Import and Reason of this Name is not well accounted for by any Writer of *Astronomy*, as I know of.

reckoned

Of the Celestial Globe, &c. 132

reckoned the ten principal Circles of the Globe, *viz.* the *Horizon*, the *Meridian*, the *Equator*, the *Zodiack* or *Ecliptick*, the two *Colures*, the two *Tropicks*, and the two *Polar* Circles. And these are distinguished into *greater* and *lesser* Circles; the six former being greater Circles, as being concentrical with the Globe it self, and so dividing, each of them, the Globe into two Hemispheres or equal Parts; the four latter being lesser Circles, as being not concentrical with the Globe, and so dividing, each of them, the Globe into two unequal Parts.

All the ten Circles last mentioned, are usually drawn on the terrestrial ^{38.} *Globe*; as also Circles crossing per-^{Of the ter-}pendicularly the *Equator* at every ten^{restrial} Degrees, and other Circles running ^{Globe.} parallel to the *Equator* at every ten Degrees. The former are called Circles of *Longitude*, the latter Circles or Parallels of *Latitude*; forasmuch as those serve to shew the Longitude of Places, (*i. e.* their Distance from some one of the said Circles taken at Liberty, and commonly called the first

124 Of the Celestial Globe, &c.

first *Meridian*, all these Circles of Longitudes being also *Meridians*;) these serving to shew the Latitude of Places, or their Distance from the *Equator*. Besides these Circles fore-mentioned, there are also usually drawn on the Surface of the terrestrial Globe, *Rumbs*, i. e. Circles crossing one another in some certain Points of the Globe, where there is a Vacancy, and representing the several Winds, or 32 Points of the Compass, set down also on the outward Rim of the *Horizon*, both of the celestial and terrestrial Globe. But the main Difference between these two Globes, is this, that on the Surface of the celestial Globe are described the Constellations, and other fixed Stars in their due Situation; on the Surface of the Terrestrial Globe are described the several Parts of the Earth and Sea in their due Situation.

39.
An Obser-
vation con-
cerning the
Difference
between
the natural
Appea-

Proceed we now to the Use of the celestial Globe, or to shew how the diurnal *Phænomena* of the celestial Lights are represented thereby. For the clearer Apprehension whereof it seems requisite to observe, that there
is

Of the Celestial Globe, &c. 125

is this Difference in general between the natural Appearances of the celestial Lights, and the artificial Representation of them by the Globe, *viz.* that the said celestial Lights do naturally appear to us as in the *Concave* or inner Surface of the Heavens, whereas they are represented upon the *Convex* or outer Surface of the celestial Globe. Wherefore to make the artificial Representation to answer more exactly to the natural Appearance, either the Spectator must be conceived to be placed within the celestial Globe at its Center, and the Body of the Globe to be transparent like the Heavens, and in such a Position of the Eye, the celestial *Phænomena* on the Surface of the Globe will appear to the Eye in a concave Surface, as they do naturally; or else the Spectator is to be conceived as placed without the concave or inner Surface of the Heavens; and consequently as viewing, from somewhere above, the correspondent convex Surface of the Heavens; and upon such a Supposition, the celestial *Phænomena* would naturally appear to us in a convex

ances of
the celesti-
al Lights,
and the ar-
tificial Re-
presentati-
on of them
upon the
celestial
Globe.

convex Surface, as they are represented by the Globe. Now we being placed upon the Convex, or outer Surface of the Earth, and the several Parts of the Earth and Sea being represented likewise on the convex Surface of the terrestrial Globe ; therefore there is an exact Agreement in this Particular between the natural Position of the several Parts of the Earth and Sea, and their artificial Representation by the terrestrial Globe, without the Help of any such Fiction, as has been afore observed requisite, to adjust the natural Appearance of the celestial *Phænomena*, to their artificial Representation by the celestial Globe.

C H A P. X.

Of the more useful Problems solved by the Celestial Globe.

P R O B L E M I.

To find the Sun's Place in the Ecliptick for any Day given, v. g. Oct. 13. Old Style.

IN the *Julian* Calendar (placed next to the *Ecliptick*) on the *Horizontal* wooden Circle of the Globe find the Day given, to which adjoins the Degree of the *Ecliptick*, where the Sun is that Day. Thus to *Oct. 13*, adjoins the first Degree of *Scorpio*, the Sun's Place for that Day.

The Sun's Place being thus found by the *Ecliptick* on the *Horizon*, the same Degree of the *Ecliptick* on the Surface of the Globe is to be taken, in order to solve any of the following Problems:

P R O-

P R O B L E M II.

To find the Sun's Declination at
any Time given, v. gr. Oct.
13. Old Style.

HAVING (by *Problem I.*) found the Degree of the *Ecliptick*, wherein the Sun is at the Time given, bring the said Degree to the graduated Edge of the *Meridian* of the Globe; the Degrees of the said *Meridian*, intercepted between the *Equator* and the Sun's Place, shews the Sun's Declination. Thus, Oct. 13. the Sun is in the eleventh Degree of the southern Declination.

As in this, so in the following Problems, by bringing any Point of the Globe to the *Meridian*, is understood the bringing it to the graduated Edge of the *Meridian* of the Globe, as being that which represents the true *Meridian*.

In like manner, the *Latitude* of a Place is found upon the terrestrial Globe, by bringing the Place to the graduated Edge of the *Meridian*, and reckoning the Degrees of the *Meridian* between the Place and the *Equator*. For as the Distance of any Point in the Heavens from the *Equator* is *Astronomical Declination*, so the Distance of any Point on the Earth from the *Equator* is *Geographical Latitude*. Which is requisite to be here known, forasmuch as although the two foregoing Problems respect indifferently all Latitudes and Places, the following Problems respect only particular Places, the *Phænomena* relating thereto varying according to the different Latitude of Places.

P R O-

P R O B L E M III.

To rectify the Globe to any Latitude given.

MOVE the respective Pole (*viz.* the north Pole, if the Latitude given be northern; the south Pole, if southern) above the *Horizon*, till there are so many Degrees of the *Meridian* between the said Pole and the *Horizon*, as answer to the Latitude given. Thus the north Pole being elevated 51 Degrees and an Half, the Globe is rectified for the Latitude of *London*.

PROBLEM IV.

*To find what Stars never rise,
or never set in any Place or
Latitude given.*

THE Globe being (by Problem 3.) rectified to the Latitude given, such Stars as go not under the *Horizon* of the Globe, during its whole Revolution, they never set in the Latitude given. And such Stars as rise not above the *Horizon* of the Globe, during its whole Revolution, they never rise in the Latitude given. Thus the little *Bear*, the *Dragon*, *Cepheus*, and *Cassiopeia*, never set in the Latitude of *London*; as also the great *Bear*, except the lower Part of its right Foot. On the other hand, the *Peacock*, the *Indian*, the *Toucan*, the *Hydrus*, the *Dorado*, the *Chamæleon*, the southern *Triangle*, the *Apus*, never rise in the Latitude of *London*.

P R O-

PROBLEM V.

To rectify the Globe, so, as that it may be ready duly to represent the diurnal Phænomena, at any Place, and Time given; v. gr. at London, Oct. 13. Old Style.

THE Globe being rectified (by *Problem 3.*) to the Latitude of the Place given, bring the Sun's Place in the *Ecliptick* for the Day given (found by *Problem 1.*) to the *Meridian*, and make the Hour-Index to point just to 12 on the Hour Circle. The Globe in such its Position will actually represent the Position of the Heavens, in Respect of the Place given, at the *Noon* or 12 a Clock of the Day given. And consequently by the due Motion of the Globe, may be represented the Position of the Heavens, in Respect of the Place

K 2

given,

given, at *any other* Part of the Day given.

Thus the north Pole being elevated $51\frac{1}{2}$ Degrees, which is the Latitude of *London*, and the first ^PDegree of *Scorpio* (which is the Sun's ^Place, *Oct.* 13. Old Style,) being brought to the *Meridian*, the Globe will represent the Position of the Heavens in Respect of *London*, at Noon, *Oct.* 13. Old Style; that is, such Stars as are at or near the *Meridian* or *Horizon* (&c.) of the Globe, will then be respectively at or near the *Horizon* (&c.) of *London*. And consequently by the due Motion of the Globe, may be represented the Position of the Heavens in Respect of *London*, at any other Hour of the same Day; and thereby may be found the Time of the Sun's Rising or Setting, &c. that Day, as is shewn in the following Problems. Only it must be remembered, that in Order to solve such Problems, as relate to the Time of any such *Phænomenon*, the Hour-Index must always be put exactly to 12 on the Hour-Circle, before the Sun's Place be moved from the *Meridian*;

dian; and also special Care must be taken, that the Hour-Index moves duly round with the Body of the Globe.

P R O B L E M VI.

To find the Time of the Sun's Rising and Setting, and its Amplitude, at any Place or Time given.

THE Globe being (by *Problem 5.*) duly ordered and prepared, turn the Globe, till the Degree of the *Ecliptick*, wherein the Sun is for the Day given, comes to the East Side of the *Horizon*; the Hour-Index will then shew upon the Hour-Circle the Time of the Sun's Rising: and the Degrees of the *Horizon*, intercepted between the true east Point, and that Point of the *Horizon* the Sun's Place comes to, shew its Morning *Amplitude*,

K 3

tude, this being the Distance of the Point of the *Horizon* where the Sun rises, from the true east Point of the *Horizon*. In like manner, the Degree of the *Ecliptick*, wherein the Sun is, being brought to the west Side of the *Horizon*, the Hour-Circle will shew the Time of the Sun's Setting; and the Degrees of the *Horizon*, intercepted between the true west Point, and that Point of the *Horizon* which the Sun's Place is brought to, shew its Evening *Amplitude*, or how far the Sun sets distant from the true west Point. Where it is to be noted, that the Sun sets so long before or after six in the Evening, as it rises after or before six in the Morning; and in like manner, the Sun sets so far distant (northward or southward, according to the respective Time of the Year) from the true west Point, as it rises from the true east Point.

Thus it will be found by the Globe, that at *London*, Oct. 13. the Sun rises much about 7, and sets much about 5 a Clock; as also, that its *Amplitude* is 18 Degrees, the Sun
 rising

rising so many Degrees to the South of the true east Point, and setting so many Degrees south of the west Point.

The Time of the Sun's Setting, being doubled, will give the Length of the Day; and the Time of the Sun's Rising, being doubled, will give the Length of the Night. Thus, Oct. 13. the Day in the Latitude of *London*, is much about ten Hours long; and the Night much about 14 Hours long.

P R O B L E M VII.

To find the Time of the Sun's Rising and Setting by its Ascensional Difference.

TH A T Degree of the *Equator*, which, reckoned from the Beginning of *Aries*, rises or sets with

the Sun in a right Sphere, is called the Sun's *right Ascension*. And that Degree of the *Equator*, which, reckoned in like manner, rises or sets with the Sun in an oblique Sphere, is called the Sun's *oblique Ascension*. And the Difference between its right and oblique Ascension, is called its *ascensional Difference*.

The oblique Ascension of the Sun, is found (the Globe being first rectified by *Problem 5.*) by bringing the Sun's Place to the East or West Side of the *Horizon*, and there noting what Degree of the *Equator* comes to the same Side of the *Horizon*, together with the Sun. The right Ascension of the Sun, is likewise found by (putting the Globe into a right Sphere, and then noting what Degree of the *Equator* comes together with the Sun to the same Side of the *Horizon*; or more readily and without changing the Globe from an oblique into a right Sphere, by) noting what Degree of the *Equator* comes up to the *Meridian*, together with the Sun: (for the *Equator* always cuts the *Meridian* at right Angles, as it does the *Horizon*.)

Horizon in a right Sphere ; and consequently, the same Degree of the *Equator*, that would come, together with the Sun, or any Degree of the *Ecliptick*, to the *Horizon* in a right Sphere, will come, together with the Sun, to the *Meridian* in any oblique Sphere.) The quantities of the right and oblique Ascension being thus found, the ascensional Difference is found by subtracting the lesser out of the greater.

Now the right Ascension of the Sun being that Degree of the *Equator*, which rises and sets with the Sun in a right Sphere, *i. e.* to such as live just under the Celestial (or upon the Terrestrial) *Equator*, to whom the Sun always rises at six, and sets at six ; hence the ascensional Difference (turned into Time by reckoning one Hour for every 15 Degrees, and so proportionably) shews how long the Sun rises and sets afore or after six, according to the Time of the Year.

Thus

Thus the Sun's right Ascension, *Oct.* 13. is much about 208; and his oblique Ascension on that Day in Respect of *London*, is much about 223; and consequently, the ascensional Difference is 15, which answers to one Hour in Time. Wherefore, the Time of the Year considered, the Sun rises much about an Hour after six, *i. e.* much about seven; and sets much about an Hour before six, *i. e.* much about five; agreeably to what was found by *Problem* 6.

PROBLEM VIII.

To find the Sun's Altitude at any Place and Time given.

THE Globe being rectified by *Problem* 5th, the Degrees of the *Meridian* reckoned from (the South Side of) the *Horizon* to the Sun's Place, give the Sun's *Meridian* Altitude.

Celestial Globe.

tude. Thus, *Oct.* 13. the *Meridian* Altitude of the Sun at *London*, will be much about 27 Degrees.

The Altitude of the Sun is found at any other Time of the Day given, by turning the Globe (rectified also by *Problem* 5.) till the Hour-Index points to the Time assigned; and then fastening the Quadrant of Altitude on to the *Meridian* at the *Zenith*; (i. e. at so many Degrees from the *Equator*, as is the Latitude of the Place given;) and bringing the said Quadrant so fastened to the Sun's Place in the *Ecliptick*: the Degrees intercepted on the Quadrant between the Sun's Place and the *Horizon*, shew the Sun's Altitude at the Time assigned. Thus, *Oct.* 13. the Sun's Altitude at nine in the Morning, will be about 17 Degrees in Respect of the *Horizon* of *London*. And the same will be its Altitude at three in the Afternoon. For it is to be noted, that at Times equally distant (before and after) from 12, the Sun's Altitude is also equal.

P R O-

P R O B L E M IX.

To represent the Face or Appearance of the Heavens, or to shew the Situation of the fixed Stars, at any Time of the Night, in Respect of any Place and Night given.

THE Globe being rectified by *Problem 5th*, and (by the Needle) set so, as that its cardinal Points answer the cardinal Points of the Compass, turn the Globe till the Hour-Index Points to the Time of the Night assigned. Such Stars as appear at or near the *Meridian* or *Horizon* (and so of any intermediate Point) of the Globe, will appear likewise at or near the *Meridian* or *Horizon* of the Place given; (and so of any intermediate Point in the Heavens.)

Thus,

Thus, Oct. 13. at Ten at Night, the glorious Constellation *Orion* will appear on the East Side of the *Horizon* of *London*; the Star *Rigel* in the left Knee of *Orion* being just at the *Horizon*; the three Stars in the same Constellation, called by our common People the *Yard*, a little above the *Horizon*. About twenty Degrees (on a vertical Circle) above the uppermost of these appears the bright Star in *Taurus*, called *Aldebaran*, and the *Bulls Eye*; and somewhat above this in the same Constellation, the Celebrated Stars called the *Hyades*, and the *Pleiades*, these being in the Back, those in the Forehead of *Taurus*. Just under the *Meridian* Southward appears the Star called *Andromeda's Head*, and at or near the *Meridian* the Constellations of *Cassiopea*, *Cepheus*, *Pegasus*, &c. Between the *Meridian* and the West Side of the *Horizon* appears the Constellations of the *Swan*, *Harp*, &c. And at or near the West Side of the *Horizon*, the Constellations of *Antinous*, *Serpentarius*, the *northern Crown*, &c.

Hence

Hence it is obvious, that this Problem is of good Use to find out and know the several Constellations, and the more remarkable Stars in each Constellation.

P R O B L E M X.

To find the Hour of the Night, the Altitude of any Star being given, or first found by some Instrument for that Purpose.

THE Globe being rectified according to Problem 5. and the Quadrant of *Altitude* duly fixed to the *Meridian*, move the Globe till the said Quadrant cross the Star in the given Altitude; then the Hour-Index will shew the Hour of the Night.

Thus,

Thus, Oct. 13. the Altitude of *Aldebaran*, or the Bull's Eye is found to be 27 Degrees, 30 Minutes. Wherefore moving the Globe till the Quadrant of Altitude crosses the said Star in $27\frac{1}{2}$ Degrees of Altitude, the Hour-Index will then Point to Ten at Night.

Here it is obvious, that if the Star be in the *Meridian*, then there is Occasion only to turn the Globe (rectified by *Problem 5.*) till the said Star comes to the *Meridian* of the Globe: for then the Hour-Index will shew the Hour.

PRO-

PROBLEM XI.

*To find the Beginning of the
(Crepusculum, i. e.) Twilight,
or the Time of the Day-break,
at any proper Time of the Year.*

THE Globe being (by Problem 5.) rectified; elevate that Degree of the *Ecliptick*, which is diametrically opposite to the Sun's Place at the Time given, 18 Degrees above the West Side of the *Horizon*; and the Hour-Index will shew the Time sought. Thus, Oct. 13. Day breaks, or the Twilight begins about a Quarter before five at *London*.

The Reason of elevating the Degree of the *Ecliptick*, diametrically opposite to the Sun's Place, 18 Degrees above the West Side of the *Horizon*, is this; because, thereby the Degree of the *Ecliptick* wherein the Sun is at the Time given, is depressed 18 Degrees below the East Side of
the

the *Horizon*. At which Depression it is observed by *Astronomers*, that the morning Twilight begins; as also, that the evening Twilight ends at the like Depression of the Sun, under the west Side of the *Horizon*. Whence it is obvious, that the Beginning of the morning Twilight being found, it is obvious to know, when the evening Twilight ends; this ending so much after or before six in the Evening, as that begins before or after six in the Morning. Thus, *Oct. 13.* the evening Twilight ends about a Quarter after eleven, at *London*, or any Place in the same Latitude.

It is to be further noted, that, the morning Twilight beginning, when the Sun is 18 Degrees below the east Side of the *Horizon*; and the evening Twilight ending, when the Sun is 18 Degrees below the west Side of the *Horizon*, it thence follows, that, during that Part of the Year, wherein the Sun's Depression is never so much as 18 Degrees, there is no Beginning of the morning Twilight, or Ending of the evening Twilight, but one continued Twilight from Sun-setting
L to

to Sun-rising. Now that Part of the Year, wherein there is such a continued Twilight in the Latitude of *London*, is while the Sun is passing from about the fifth Degree of *Gemini*, to the twentieth of *Cancer*, i. e. from about the 15th of *May*, to about the 7th of *July*. For during this Space, the Sun is never depressed 18 Degrees below the *Horizon*.

PROBLEM XII.

To find the Longitude and Latitude of any Star given.

I A Y one End of the Quadrant of Altitude upon the proper Pole of the *Ecliptick*; (viz. if the Star be in the northern Hemisphere of the Heavens, upon the north Pole; otherwise, on the south Pole,) and the graduated Edge thereof upon the Center of the Star, so will the Quadrant cut the *Ecliptick* in the Star's Longitude,

Longitude, (i. e. its Distance from the first of *Aries*,) and the Degrees of the Quadrant intercepted at the same Time, between the Star and the *Ecliptick* will give its *Latitude*, this being no other than the Star's Distance from the *Ecliptick*. Thus the Longitude of the Star called *Lucida Lyræ*, will be found to be 283 Degrees and its Latitude about 60 Degrees Northwards.

It is obvious, that the Sun, being always in the *Ecliptick*, never hath any Latitude; and its Longitude is found without any more ado, than by computing the Number of the Degree it is in from the first of *Aries*. Thus, Oct. 13. the Sun is in the 190th Degree of *Longitude*, that being the Distance or Number of the first Degree of *Scorpio*, where the Sun then is, from the first of *Aries*.

There are some other Problems, which may be solved by the Globe; but they being of little Use are here omitted. And so we are come to the End of this Astronomical Treatise,

Of the Use of the, &c.

wherein are contained such Particulars, as seem more useful to be known by Young Students, especially Young *Gentlemen*, at their first Institution in *Astronomy*.

F I N I S.



T H E
Young Gentleman's
CHRONOLOGY,

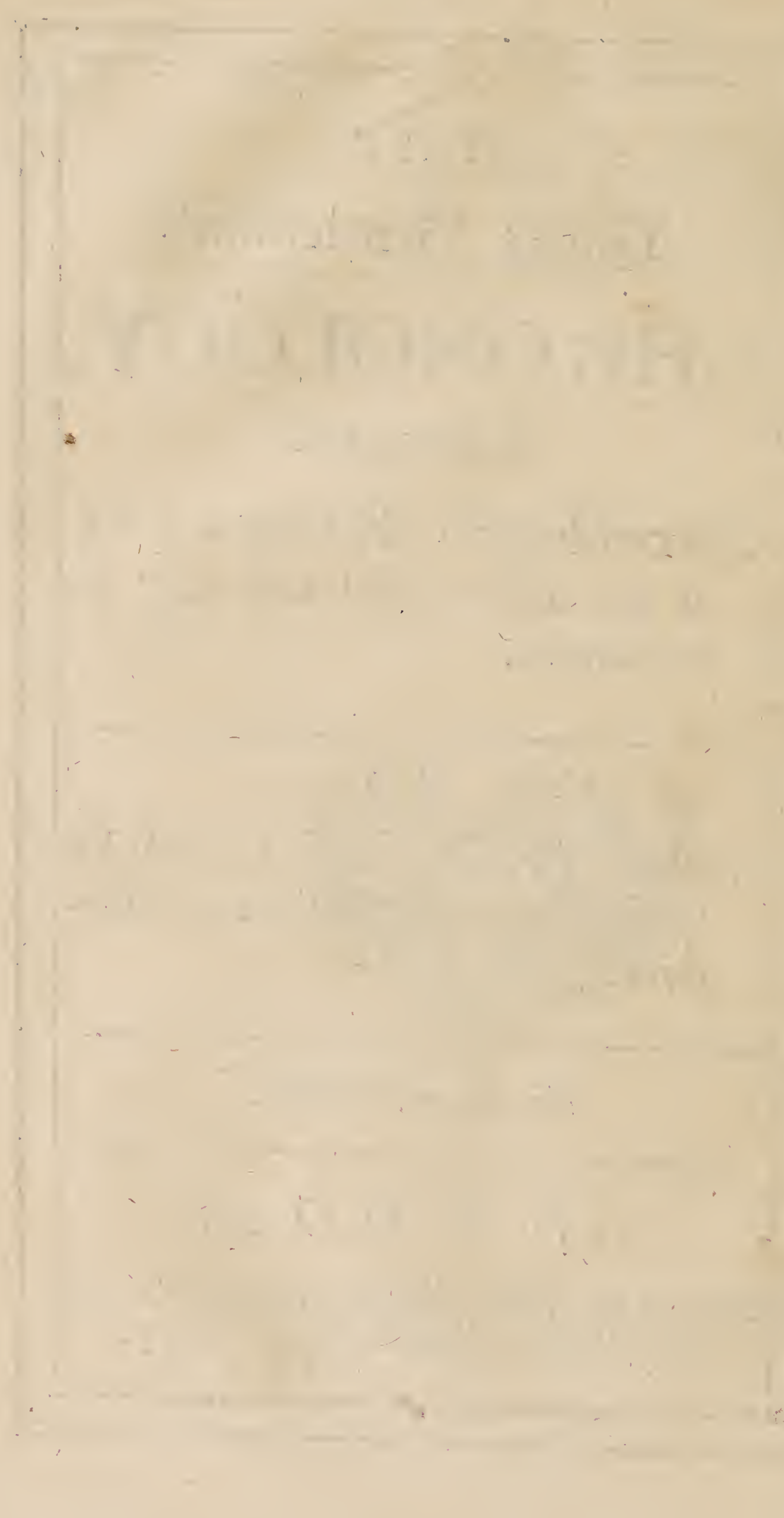
Containing such
Chronological E L E M E N T S,
as are most useful and easy to
be known.

B Y
EDWARD WELLS, D. D.
Rector of *Cotesbach* in *Leicestershire*.

The Second Edition.

L O N D O N,

Printed for *James Knapton*, at the *Crown*
in *St. Paul's Church-Yard*. 1717.



T H E

P R E F A C E.

THE Art of Chronology has so close a Dependence upon Astronomy, that it is not unusual for Writers of Astronomical Treatises to comprise therein a great deal of what more properly belongs to Chronology ; and which therefore I have here laid
L 4 together,

The Preface.

together, with the other most useful and easy Elements of Chronology, in a distinct Treatise from my Astronomy. But the Design both of the One and the Other being the same, as therefore I have given my Astronomical Treatise the Title of The Young Gentleman's Astronomy, so I have given this my Chronological Treatise the Title of The Young Gentleman's Chronology ; nothing being herein insisted on, but what relates to the common (Civil or Ecclesiastical) Computation of Time, and to the
two

The Preface.

two Celebrated Era's of the Olympiads, and the Building of Rome, the former chiefly used by Greek Historians, the latter by Roman.



THE

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T H E
Young Gentleman's
C H R O N O L O G Y, &c.

C H A P. I.

*Of a Day ; and the Parts of Time
arising from a Day by Division,
viz. Hours and Minutes.*

BY (*) *Chronology* is understood
the Art or Skill of adjusting ^{I.} Chronolo-
Things past to their propriety, *what.*
Times.

Hence Chronological Institutions
consist of the Explication of the seve- ^{2.} Distin-
guish'd into
two Parts.

(*) The Word *Chronology* denotes literally in the
Greek Language a Discourse or Account of Time, being
compounded of χρόνος & Time, and λόγος & a Discourse
or Account.

ral

ral *Parts*, into which Time in general is divided; and of the several *Characters*, by which particular Times are distinguished one from another.

3. *All other Parts of Time arise from a Day, either by Division, or Collection.* The several Parts of Time are, *Minutes, Hours, Days, Weeks, Months, and Years*. Amongst which we shall speak first of a Day, because from it arise the other Parts of Time, considered as they are applied to common Use. For as Hours and Minutes arise from a Day by Division and Subdivision; so Weeks, Months, and Years arise from a Day by Collection, or reckoning such or such a Number of Days together.

4. *A Day, what, primarily and properly.* By a *Day* then, according to the primary (†) Intention of the Name, is denoted the Time of Light; and in this Sense it is opposed to Night, or the Time of Darknes. And the Sun being made to (||) rule the *Day*, hence a Day, according to the primary Intention of the Name seems most properly and naturally to be determined

(†) God called the Light Day; and the Darknes he called Night, Gen. 1. 5.

(||) God made two great Lights; the greater Light to rule the Day, Gen. 1. 16.

Of Days.

3

by the Sun's Rising and Setting ; and so to be most properly and naturally defined, the Stay of the Sun above the Horizon, or the Time between the Sun's Rising and Setting. Agreeably whereunto. Night is the Stay of the Sun below the Horizon, or the Time between the Sun's Setting and Rising.

But the Word *Day* is frequently taken in a larger Sense, so as to comprehend also the Night, and to denote a whole Revolution of the Sun round the Earth. This Sort of Day is most aptly denoted by the Greek Word (*) *Nuchthemeron*. 5. Another Acceptation of a Day for a Nuchthemeron, or 24 Hours.

The *Nuchthemeron* may be reckoned, either from Sun-setting to Sun-setting, as did the *Jews* and *Athenians*, and as the *Italians* still do ; or from Sun-rising to Sun-rising, as did the *Babylonians* ; or from Mid-day to Mid-day, as do the Generality of 6. Different ways of computing the Nuchthemeron.

(*) It is a compound of *νύξ* a Night, and *ἡμέρα* a Day. The two-fold Acceptation of the Word *Day*, is distinguished usually by the Names of a *Natural* and an *Artificial* Day. But some calling that a natural Day, which others call an Artificial, hence arises great Confusion ; to avoid which I judge it best, wholly to omit this Distinction.

Astrono-

Astronomers, and likewise the *Arabs*,
or lastly, from Mid-night to Mid-
night, as did the old *Egyptians*, and
We of this Island, together with the
French, *Germans*, and other *Europeans*
still do.

7.
Of an
Hour.

Proceed we now to the Part of
Time, called an *Hour*. And hereby
is principally denoted the 24th Part
of a *Nuchthemeron*. Now a *Nuchthe-
meron* being the Space of an entire Re-
volution of the Sun about the Earth,
during which the Equator makes also
an (†) entire Revolution, hence it

(†) In strictness the Equator makes somewhat more
than one Revolution, during a *Nuchthemeron*; viz. so
much more as answers to the Sun's apparent proper
Motion in the Ecliptick during the said Space of Time.
Now this Overplus being various, viz. 57 Minutes in
the Sun's Apogee; and 61 Minutes in its Perigee; hence
Astronomers take the Mean between the two fore-men-
tioned Numbers for a standing Measure through the
whole Year, and so compute that to every *Nuchtheme-
ron* there answers 59', 8'', and almost 20''', over and
above a Revolution (or the 360 Degrees) of the Equa-
tor. But now the Difference between the Sun's Revo-
lution (or a *Nuchthemeron*) and the Equator's, when at
greatest, being but 61 Minutes, or a little more than a
Degree, which answers but to a little more than 4
Minutes in Time, hence it may be passed over unre-
garded in common Use; and the Hour here spoken of
may be well enough esteemed to answer just to 15
Degrees of the Equator.

comes

Of Minutes.

comes to pass, that as the whole Circle or all the 360 Degrees of the Equator answer to a whole *Nuchthemeron*, so a 24th Part or 15 Degrees of the Equator answer to a 24th Part of a *Nuchthemeron*, or such an Hour. And because these Hours are all thus usually measured by 15 Degrees of the Equator, hence they are all looked on as *Equal* one to another at all Times.

But the *Jews, Greeks, and Romans* ^{8.} did antiently divide (not the *Nuchthemeron* into 24 equal Hours, but) the Day, whether longer or shorter, into 12 Hours; and so likewise the Night. Whence it is obvious, that their Hours were *Unequal* one to another, except only at the two (||) Equinoxes; when the Day and Night being Equal, their Hours would likewise be Equal, and so the same as to Extent with our Hours; though not as to Denomination.

Of Temporary or unequal Hours.

(||) Hence the equal Hours used by us are sometimes stiled *Equinoctial* Hours; and the unequal Hours used by the *Jews, &c.* are stiled *Temporary* Hours, from their varying in Length according to the other various Parts of the Year.

9. For they always reckoning their first Hour of the Day from the Sun's Rising, which at the Equinoxes answers exactly to our six a Clock in the Morning, it follows that their first Hour of the Day must answer at the Equinoxes to our seven a Clock in the Morning; and consequently their third Hour to our nine a Clock in the Morning; their sixth to our twelve a Clock at Noon; their ninth to our three a Clock in the Afternoon, &c. And although there is not so exact a Correipondence between the Hours used by them and us, at other Times of the Year, yet the fore-mentioned Observation is of good Use for the better Understanding the several Hours of the Day mentioned in the Sacred History.

10. Upon the like Account it is not to be here omitted, that the *Jews* divided the Night (not only into twelve Hours, as is afore observed; but also) into four Quarters, called *Watches*, each Watch containing three of their Night-hours. These Watches were distinguished, either by their numeral Order, whence we expressly read in the

Of Minutes.

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the Sacred History of the (*) *Second*, *Third*, and (†) *Fourth* Watch; or by some other Denomination. Thus the first Watch is otherwise stiled the (||) *Head or Beginning of the Watches*; the Second, the (*) *Middle* Watch, because it lasted till Mid-night; and the Fourth, the (†) *Morning* Watch. Again, the First was termed (||) the *Evening*; the Second, *Nid-night*; the Third, the *Cock-crowing*; the Fourth, the *Dawning*.

The common Division of an Hour is into *Quarters*. But Astronomers, and such as are more accurate in counting Time, divide an Hour into sixty Parts, called *Minutes*; and a Minute again into sixty Parts, called *Seconds*, as being Minutes of Minutes, and so secondary Minutes. And here it is to be observed, that the Word *Minute* is taken in a double Sense, either to denote the sixtieth Part of an Hour, which therefore is peculiarly stiled an *Horary Minute*; or else to denote the sixtieth Part of a Degree,

it is
of Mi-
nutes, and
Seconds;
and the
Difference
between
Horary
and Gra-
duary Mi-
nutes.

(*) Luk. 12. 38. (†) Matt. 14. 25. (||) Lam. 2. 19. (*) Judg. 7. 19. (†) Exod. 14. 24. (||) Mark 13. 35.

Of Minutes

which therefore may be distinguished by the Name of a *Graduary Minute*. And this *Graduary Minute* is subdivided by Astronomers into sixty *Seconds*, and also each *Second* into sixty *Thirds*, and each *Third* into sixty *Fourths*, &c. whereas it is usual to subdivide an *Horary Minute* only into *Seconds*. Now as 15 Degrees of the Equator answer to one Hour or sixty *Horary Minutes*, so one Degree of the Equator or sixty *Graduary Minutes* answer to four *Horary Minutes*; and so one *Horary Minute* to fifteen *Graduary Minutes*. And thus much for the several Parts of Time, which arise from a Day by Division, and Subdivision.

C H A P.

C H A P. II.

*Of the several Parts of Time,
which arise from a Day by
Collection; viz. Weeks, Months,
and Years.*

AMong the several Parts of Time, ^{I.} which arise from a Day by Col- ^{Of a Week properly so called.}lection, it is proper to speak first of the *Week*, not only as denoting the smallest Collection of Days, namely, no more than seven; but also as being the most Antient Collection, as we learn from the Sacred History, whereby we are taught that it was instituted presently after the Creation, and in Memory of God's creating the World in six Days, *and resting on the Seventh from all his Works, which he had made.*

The seven Days of the Week are ^{2.} commonly distinguished by the Name ^{The seven Days of the Week, whence} of the Planets, accounted also just ^{take their} seven according to the Vulgar System, and placed in this Order from the ^{common} Highest to the Lowest, ^{Denomi-} viz. Saturn, ^{nations.} Jupiter,

Of Weeks.

Jupiter, Mars, the Sun, Venus, Mercury, and the Moon. Now the Astrologers supposing the fore-mentioned Planets to preside or rule over the several Hours of the *Nuchthemeron* according to their Order above-mentioned, hence denominate each Day of the Week from that Planet, which is supposed to preside over the first Hour of the *Nuchthemeron*. Whence it comes to pass, that the Days are denominated from the Planets according to the common Method. For assigning the first Hour of *Saturday* to *Saturn*, the second will fall to *Jupiter*, the third to *Mars*, the fourth to the *Sun*, the fifth to *Venus*, the sixth to *Mercury*, and the seventh to the *Moon*. And so the eighth Hour will fall to *Saturn* again, and also the fifteenth and twenty-second of the said *Nuchthemeron*; and consequently, the twenty-third Hour will fall to *Jupiter*, the twenty-fourth to *Mars*. By which means the first Hour of the next *Nuchthemeron* will fall to the *Sun*, and the first Hour of the next to the *Moon*, of the next to *Mars*, of the next to *Mercury*, of the next to *Jupiter*, of the next to *Venus*; and of the next to *Saturn*

Of Weeks.

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turn again, and so through the next Week as afore. Hence the Days of the Week came to be distinguished in their Order by the *Latin* Names of *Dies Saturni, Solis, Lunæ, Martis, Mercurii, Jovis, and Veneris*; and so among us by the Names of *Saturday, Sunday, Munday, Tuesday, Wednesday, Thursday, and Friday*. For as *Saturday, Sunday, and Munday*, plainly denote the Day of *Saturn*, the *Sun*, and the *Moon*; so *Tuesday, Wednesday, Thursday, and Friday*, denote the Day of *Tuisco, Woden, Thor, and Friga*; which are the *Saxon* Names respectively answering to *Mars, Mercury, Jupiter, and Venus*.

It is also not to be omitted, that, because the *Easter Week* was formerly esteemed the First or Principal Week of the Year; and each Day thereof was a *Feria* or *Holy-Day*; hence the several Days of the Week were distinguished in their respective Order, among the Primitive Christians, by the Names of *feria Prima, Secunda, &c. i. e. the First, Second, (&c.) Holy-Day*: *Sunday*, or the *feria Prima* being otherwise stiled by them *the Lord's*

3.
The Days
of the Week
how deno-
minated by
the Anti-
ent Chri-
stians.

M 4

Day,

Of Weeks.

Day, as being the Day of our Lord's Resurrection.

4.
A Week
sometimes
taken to
denote the
Space of
seven
Years.

Hitherto we have spoken of a Week in its common Acceptation, as it denotes *a Week of Days*, or *seven Days*. But it is not wholly to be past by, that as the Original or *Hebrew* Word which we render a Week, does literally denote only in general a *Collection of Seven*, and therefore may be applied to Years as well as Days, (and the same holds as to the correspondent (*) *Greek* and *Latin* Words,) so it is actually used in (†) some Places of the Sacred History to denote, not *seven Days*, but *seven Years*. And in Conformity to the Use of the said Original Word, our *English* Word *Week* is used in the said Places of Sacred Scripture to denote, not *a Week of Days*, but *a Week of Years*, or a Collection of seven Years.

5.
A Syro-
cal Month,
primarily
called a
Month.

Proceed we next to speak of *Months*, which, as they are of various Sorts, so are called by this one common Name, not by mere Chance, or without any Reason, but by Reason of

(*) *Hebdomas* and *Septimana*.

24—27.

(†) So Dan. 9.

their

Of Months.

13

their all agreeing in some Relation to a Month primarily so called. Now the (||) *Hebrew* Word, to which our Word *Month* answers, does literally import the Time from one *New Moon* to another; and so does properly denote a *Synodical Month*. And forasmuch as this Sort of Month is most distinguishable by our Sense, and so most obvious and proper to be used as a Measure of Time in the common Affairs of Life; hence it is more than probable, that, as our Word *Month* is evidently derived from the Word *Moon*, so it was primarily intended to denote likewise the Time from one New Moon to another, or a *Synodical Month*. For it is more than probable, that this Word in our Language (and so of the correspondent Words in all other Languages) was first used to denote that Sort of Month, which was first observed as a Measure of Time. But now it is not reasonably to be

(||) The *Hebrew* Word *Chodesh* (is derived from a *Radix*, which signifies to *Renew*, and accordingly) does primarily denote the *New Moon*, or the *Day of the New Moon*; and thence it is secondarily taken to denote a *Month*, being the Space from one New Moon to another.

doubted,

doubted, but the Synodical Month was first used as a Measure of Time, forasmuch as it is obvious to the bare Sense, even of the Vulgar and most illiterate Persons.

5.
The Periodical
Month why
called a
Month.

As for the *Periodical Month*, or the Time wherein the Moon goes round her *Orbit*, this could not be determined without some Observation and Study; and therefore no doubt was not taken Notice of, till sometime after the Synodical Month was used. And consequently it is not to be doubted, but the Name *Month* was applied to the Time of the Moon's Periodical Course, not primarily, but secondarily, or after it had for some Time been applied to the Moon's Synodical Course. And the Reason of imposing the same Name upon the Time of that, as had been imposed afore upon the Time of this, was, because both Times agree in the general, *viz.* as they relate to the Course of the Moon, and so may both from the *Moon* be called *Months*.

6. It has been afore (in the Astronomical Treatise, Chap. 4. Sect. 2, 3.) observed, that the Periodical Month consists of 27 Days and $7\frac{3}{4}$ Hours; and

of the different Lengths of the Syno-

Of Months.

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and the Synodical Month of 29 Days ^{dical and} and $12 \frac{3}{4}$ Hours. And the Reason of ^{Periodical} this Difference has been there accounted for. ^{Month.}

It is here to be further noted, that, ^{7.} because during (either a Synodical or ^{A Solar} Periodical) Month of the Moon, the ^{Month,} Sun passes well-nigh through a whole ^{what, and} Sign of the Ecliptick; hence the Time ^{why called} of the Sun's passing quite through a ^{a Month.} Sign is called a *Solar* Month, as nearly answering to the Space of a *Lunar* Month, especially the Synodical Month. For as this Sort of *Lunar* Month is a little above $29 \frac{1}{2}$ Days, so the fore-mentioned *Solar* Month is almost $30 \frac{1}{2}$ Days; and consequently the Difference between them is but about one Day.

But now because the fore-mention- ^{8.} ed *Solar* and *Lunar* Months do not ^{Civil} consist just of whole Days, but of ^{Months,} some odd Hours and Minutes over, ^{what, and} which cannot be considered in the ^{why called} common Account of Time; therefore ^{Months.} some certain Number of just whole Days are made use of instead of the fore-mentioned Astronomical Months; but however are called likewise *Months*, forasmuch as they come as near as can be

Of Months.

be to the said *Astronomical* Months, from which they are distinguished by the Name of *Civil* Months, as being adapted to Civil or Common Use.

9.
A Month
of Weeks,
what.

Thus in the first Place, what is most commonly called a Month among us, is made to consist just of twenty-eight whole Days, and so just of four whole Weeks; whence it is peculiarly stiled *the Month of Weeks*. It is obvious, that in Order to render the Computation of Time from Weeks to Months more easy, and so more fit for common Use, it was necessary that the Month should consist just of some certain Number of whole Weeks: which being thus necessary, four whole Weeks were made Choice of for the Number, which should constitute the Month; because this Number comes nearer than any other Number of Weeks, to the several *Astronomical* Months afore-mentioned.

10.
The Civil
Synodical
Month,
what.

The *Astronomical Synodical* Month is adapted to Civil or Common Use, by making the Civil Synodical Month to consist alternately of (*) twenty-

(*) A Civil Synodical Month consisting of thirty Days, is called *Plenus*, i. e. a Full Month; and a Civil Synodical Month consisting but of twenty-nine Days, is called *Cavus*, i. e. an *Hollow* or *Defective* Month.

Of Months.

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nine and thirty whole Days; for $29 + 30 = 59 = \frac{1}{2} \times 2$, that is, two Civil Synodical Months are equal to two Astronomical Synodical Months, omitting in both the odd Minutes. And consequently, according to this Method, the New Moon will keep to the first Day of every such Civil Month for a long Time together, when once adjusted thereto. This was the Month in Civil or Common Use among the *Jews, Greeks, and Romans*, till the Time of *Julius Cæsar*, and is still so among the *Turks*.

In like manner, the Astronomical Solar Month may be adapted to common Use, by making the Civil Solar Months to consist alternately of thirty and thirty-one Days, excepting one Month of the twelve, which should consist of thirty Days every four Years; the other three Years it must consist only of twenty-nine Days. This is illustrated by the adjoining Scheme or Table of the Solar Months.

II.

The Solar Months might be uniformly adapted to Civil or Common Use.

Months

Of Months.

Months.	Days.	Months.	Days.	Months.	Days.
<i>March</i>	31	<i>Quintilis</i>	31	<i>November</i>	31
<i>April</i>	30	<i>Sextilis</i>	30	<i>December</i>	30
<i>May</i>	31	<i>September</i>	31	<i>January</i>	30
<i>June</i>	30	<i>October.</i>	30	<i>February</i>	29

And every fourth Year, 30

For according to this regular and uniform Method, there will be 365 Days in the twelve Solar Months for three Years together, and every fourth Year 366 Days, just as it is now.

12.
The Solar
Months
how came
to be insti-
tuted, as
in Use a-
mong us.

It is evident then, that the Civil Solar Months might be thus uniformly constituted. And indeed they were so constituted in the main at first by *Julius Caesar*, who brought the Solar Months into common Use among the *Romans*, whereas they used afore the Civil Lunar Month, as was (†) observed when we were speaking of the said Lunar Month. The Alteration was made afterwards, when (as the fifth Month, which had afore been called from its Rank, *Quintilis*, was new named *Julius* in Honour of the Emperor of that Name; so) the sixth Month, which had afore been called

(†) Sect. 10th of this Chapter.

from

from its Rank, *Sextilis*, was new named *Augustus* in Memory likewise of the Emperor of the same Name; and not only so, but (whereas this Month consisted afore but of thirty Days, and so was a Day shorter than the foregoing Month of *July*,) there was a Day more added to it, that so the Honour paid to *Augustus* might not seem to fall short of the Honour paid to *Julius*, even in this Punctilio. Now this Alteration being made as to the Month of *August*, it (according to the alternate Method at first instituted, and still preserved in the following Months) made an Alteration in all the following Months, except *January*, which upon this Alteration should have had but thirty Days according to the alternate Method primarily instituted. But this Month being so named in Honour of *Janus*, esteemed by the *Romans*, the God of Time, on the like Consideration that it seem'd proper to lengthen the Month of *August* by a Day, it might seem not proper to lessen the Month of *January* by a Day; but rather to continue it still thirty-one Days long, and to make *February*, which afore was twenty-nine,

Of Months.

nine, and every fourth Year thirty Days long, to be commonly but twenty-eight, and every fourth Year but twenty-nine Days long. And so the Solar Months came to stand, as they do now in our *Calendar*, (whence they are called the *Calendar Months*) in reference to the Names and Number of Days assigned to each, set down in short in the following Table.

Months.	Days.	Months.	Days.	Months.	Days.
<i>March</i>	31	<i>July</i>	31	<i>November</i>	30
<i>April</i>	30	<i>August</i>	31	<i>December</i>	31
<i>May</i>	31	<i>September</i>	30	<i>January</i>	31
<i>June</i>	30	<i>October.</i>	31	<i>February</i>	28

But every fourth Year, 29

By comparing this and the foregoing Table, will be illustrated whatever has been here said, either concerning the first Institution of the Solar Months among the *Romans* by *Julius Cæsar*; or concerning the Changes that have been since introduced. And also it will appear, that the whole Number of Days, contained in the twelve Solar Months taken together, hath been all along the same, *viz.* 365 Days, and every fourth Year 366 Days. The former of which Sums is
the

Of Months.

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the Time, wherein the Sun seems to pass through the twelve Signs, (†) omitting the odd Hours and Minutes, and the latter Sum is the Time, wherein the Sun seems to pass through the twelve Signs, adding thereto the odd Hours and Minutes which were omitted the three foregoing Years, and so many Minutes more as make the said odd Hours and Minutes equal to a whole Day in four Years.

Now as these twelve Solar or Calendar Months make up the Civil Solar Year in use among us (in which Sense it is, that a *Twelve-Month* is used by us as an Equivalent Term to a Year) so what has been said concerning the Sums of 365 and 366 Days being contained in the twelve Calendar Months taken together, will be more particularly explained, when we come presently to speak of the Civil Year in use among us; after that we have made some short Observations concerning the Year in general.

13.
A Twelve-Month, ~~how~~
Equivalent
to a Year.

(II) See Sect. 16. of this Chapter.

14.
A Year,
what, in
general.
It is pro-
perly taken
to denote a
Solar Year.

By a (†) *Year* then (the only Part of Time remaining to be treated of) is denoted in general a Revolution of a Celestial Light round the Heavens by (what is esteemed) its proper Motion. Thus an entire (apparent) Revolution of the fixed Stars is stiled the *Great Year*; and the Time wherein *Saturn*, *Jupiter*, and *Mars*, go round their *Orbits*, is respectively stiled the Year of *Saturn*, *Jupiter*, and *Mars*; and accordingly the Time of the Moons going round her *Orbit*, commonly called her Periodical Month, is sometime stiled her Year. But by a Year is principally and properly denoted the Time, wherein the Sun appears to move round the *Ecliptick*, which is 365 Days, 5 Hours, and very near $49\frac{1}{2}$ Minutes.

15.
A Lunar
Year,
what.

Now because during the Time of one *Solar Year*, there are twelve Synodical Months; hence twelve Syno-

(†) As the *Latin Word Annus* primarily denotes a Circle (whence *Annulus* signifies a Ring) and is thence taken to denote a Year, as being a Circle of Time, which being once gone round is begun again; so the *Greek Word ἐνιαυτός*, and the *Hebrew Word Shanah* is of the like Importance.

dical

Of Years.

23

dical Months constitute (what is called) a *Lunar Year*; which therefore consists of 354 Days, 8 Hours, and a little more than 48 Minutes. So that the exact Difference between the Astronomical Solar and Lunar Year is 10 Days, 21 Hours, and 1 Minute.

But whereas the Hours and Minutes 16.
above the whole Days of a Solar The Astro-
nomical
Year, can't be taken Notice of in Ci- Solar Years
vil or Common Use; therefore the how adap-
ted to Ci-
vil or Com-
mon Use.
Civil Solar Year in use among us, is made to consist only of 365 Days for three Years together, and every fourth Year of 366 Days. Namely, whereas in an Astronomical Solar Year there are, above the whole Days, 5 Hours, and very near $49\frac{1}{2}$ Minutes; there are added every Year about 11 Minutes, to make up this just six Hours; and these six Hours amount just to a whole Day in four Years.

Each of the three Years consisting 17.
only of 365 Days, is called a *Common* A Bissex-
tile or
Leap-
Year, why
so called.
Year; and every fourth Year consist-
ing of 366 Days, is called a *Bissextile*
or *Leap-Year*. The Reason of its be-
ing called *Bissextile* is, because the
Day arising in four Years out of the
six Hours afore-mentioned, is this
C 2 Year

Of Years.

Year *intercalated*, i. e. inserted into the Calendar, by reckoning (according to the *Roman Way*, *bis sextum Kal. Martii*, i. e. by reckoning) *twice the sixth Day* before the Calends of *March*, which answers to our twenty-fourth of *February*. But although we took our Civil Solar Year from the *Romans*, yet we do not imitate them in this particular, but instead of reckoning *February* the twenty-fourth twice, we reckon this Year twenty-nine Days in *February*, whereas in common Years we reckon but twenty-eight. But although we reckon not *February* twenty-fourth twice, yet we reckon twice the Calendar Letter always belonging to *February* the twenty-fourth; namely *f*. And by this means, that which was the *Sunday Letter* from *January* the first to *February* twenty-fourth, will be so no longer, but the Letter next before it in the Order of the Alphabet, will be the *Sunday Letter* for the remaining Part of the Year. From which *Leap* or Change from one *Sunday Letter* to another, this Year came to have the Name of *Leap Year* amongst us.

It

Of Years.

25

It has been afore observed, that the Astronomical or true Solar Year does consist of 365 Days, 5 Hours, 49 $\frac{1}{2}$ Minutes. Whereas to adapt it to Civil Use, the Solar Year is conceived to consist of 365 Days, and just six Hours; (which six Hours in four Years make up just another whole Day;) so that the Civil Solar Year is about eleven Minutes longer than the true Solar Year. Hence it comes to pass, that the Seasons, or (which comes to the same) the Equinoxes and Solstices, depending on the true Solar Year, do not keep always to the same Time or Part of our Civil or Common Year, but vary every Year about eleven Minutes, (*viz.* 10', and 48',) and consequently about a whole Day in 133 Years. Wherefore from A. D. 325, when the famous *Nicene Council* was held, to A. D. 1582, wherein Pope *Gregory* the XIII. reformed the Calendar, there was found to have arose a Variation of ten Days; the Vernal Equinox, which at the Time of the *Nicene Council* fell about the 21st of *March*, in A. D. 1582, being found to fall on *March* the 11th. Hereupon the fore-mentioned Pope,

N 3

intending

18.

The Civil Solar Year too long by eleven Minutes; and of the Gregorian Reformation of the Calendar caused thereby.

intending to bring back the Equinox to the Time of the Year it fell upon at the *Nicene Council*, ordered *October 5th*, (in the Year 1582.) to be reckoned *October 15th*, thereby suppressing ten Days, and making the following *March 11th* to be reckoned *March 21st*; and so the Vernal Equinox, which otherwise would have been reckoned to fall on *March 11th*, to fall on *March 21st*, as at the Time of the *Nicene Council*. And that the like Variation might not happen again, the said *Pope* ordered, that once in 133 Years a Day should be taken out of the Calendar; or (which comes to the same) that three Days should be taken out every four Hundred Years, after this Method, *viz.* whereas, according to the Account afore (and still by us) used, every Hundredth Year from the Nativity of our Saviour is a *Leap-Year*; from thenceforth only every four Hundredth Year should be a *Leap-Year*; and the other Hundred Years should be common Years.

19. As the Account afore in use, is
 Old-Style thence called the *Old Style*; as also
 and New- the *Julian Account* or *Julian Year*,
 Style, from *Julius Caesar*, by whose Authori-
 what, ty

ty it was first introduced among the *Romans*, forty-six Years before Christ according to the Common Account by the Years of our Lord: So this Form of the Civil Solar Year introduced by the fore-mentioned *Pope Gregory*, is from him called the *Gregorian Account*; as also from its being (comparatively with the former) newly introduced, the *New-Style*. And this is used in *Italy, France, Spain*, and where-ever the *Pope's* Authority is acknowledged; and as it had been received from the first by the *Popish* Countries of *Germany*, so towards the End of the last Century it was received also by many of the *Reformed* People of *Germany*, as to their Civil or Common Account of Time. For as to their Ecclesiastical Account, or finding the (*Eastern Moon*, or) Time of *Easter*, these follow the *Rudolphine Tables* of *Kepler*. The *Old-Style* is still used by *Us* of this Island, as also in *Ireland*, and by some others.

Although the Calends or First of 20. *January* is now-adays, almost thorough-
out all *Europe*, commonly looked on as the Beginning of the Year, whether *Julian* or *Gregorian*; yet there are some, who reckon the Beginning of it from some other Part of the Year.

Of the various Beginnings of the Civil Solar Year in various Countries.

Thus the *Venetians*, *Florentines*, and *Pisans* in *Italy*, and the Inhabitants of *Triers* or *Treves* in *Germany*, reckon the Beginning of the Year from the Vernal Equinox. The Church of *England*, in Conformity to the Antient Usage of the Christian Church, reckons her Ecclesiastical Year from the Feast of the Annunciation, commonly called by us *Lady-Day*. And our Civil Year, according to our Law, takes also its Beginning from the same Day; though the common People, and others among us in Matters not requiring the Nicety of a Legal Date reckon the Beginning of our Year from the first of *January*.

21.

The Astro-
nomical
Lunar
Year how
adapted to
Civil Use;
and first of
the Wan-
ding Lu-
nar Year.

It has been afore observed, that the Lunar Year, strictly or according to Astronomical exactness, consists of 354 Days, 8 Hours, and a little more than 48 Minutes. But to adapt this also to Civil Use, the Civil Lunar Year is esteemed to consist only of 354 whole Days. So that the Difference between the Civil Lunar Year of 354 Days, and the Civil Solar Year of 365 Days, is an eleven Days; the former being so much shorter than the latter. Hence it comes to pass, that such

such as use the Civil Lunar Year, without any regard to the aforesaid Difference, their Year, supposing it to begin now in Spring, will after eight Years Time begin in Winter; and after eight Years more in Autumn, and so after that in Summer; and lastly, after about thirty three Years in all, will begin in Spring again. Hence it is called *Annus Lunaris Vagus*, or the *Wandering Lunar Year*; because its Beginning thus wanders through the several Seasons, and that in the Memory of Man. And this is the Sort of Year used by the *Turks*.

Others, though they used or use 22. the Civil Lunar Year, yet remedy the fore-mentioned Inconveniency of its thus changing the Time of its Beginning, by having Regard to the fore-mentioned Difference of eleven Days, between the Civil Solar and Lunar Year; namely, by intercalating so many Months, as the said Difference of eleven Days arise to in such a number of Years. By which means the Lunar and Solar Year are kept so adjusted one to the other, as that the Beginning of the Lunar Year will keep

Of the fixed Lunar, or Luni-Solar Year.

keep in a manner fixed to the same Part of the Solar Year. Hence this Sort of Year is called the *fixed* Lunar Year; as also the *Luni-Solar* Year; and it is used by the *Jews*, and the Church of *Rome* in her Ecclesiastical Account. And thus much for the several *Parts*, into which Time in general is distinguished.

C H A P.

C H A P. III.

Of the several Characters of Time in general; and particularly of the Cycle of the Moon, and the Epacts.

PROCEED we now to speak of the several Characters, whereby particular Times are distinguished one from the other. And these are either *Natural* or *Instituted* by Men. I. The Characters of Time two-fold.

The Natural Characters of Time are such as depend on Natural Causes, and are these; viz. *New Moons*, *Full Moons*, *Eclipses*, either of the Sun (as they are commonly call'd) or Moon, the two *Equinoxes*, the two *Solstices*, the *Cycle of the Moon*, and the *Epacts* of the Moon. All which have been sufficiently spoken of in the foregoing Treatise of Astronomy, except the *Cycle* and *Epacts* of the Moon; which are therefore to be here explained. 2. The Natural Characters of Time, what

The

Of the Cycle of the Moon.

3.
Of the Cy-
cle of the
Moon.

The Cycle of the Moon then is to be esteem'd a (†) Natural Character of Time, because it depends on a Natural Cause, *viz.* the Motion of the Moon: which is such, that, after nineteen Years very nearly, the New Moons and Full Moons are observed to fall on the same *Nuchthemeron* of the *Julian* Year, as they did nineteen Years afore. Hence this Cycle is otherwise termed the *Cycle of nineteen Years*.

4.
Of the
Golden
Number,
or Prime.

The New Moons being observed to fall out thus, they were wont formerly to calculate or find out the Time of the New Moons (without the Help of Astronomical Tables) after this manner. They observed, on what Day of each Calendar Month the New Moon fell, in each Year of this Cycle; and to the said Days they set respectively the Number of the said Year. Thus observing, that the New Moons, in the first Year of this Cycle, fell on *January 23d, February 21st, March 23d,*

(†) Some esteem this, not a *Natural*, but an *Instituted* Character of Time. But not so properly, since it depends on a *Natural* Cause.

Of the Cycle of the Moon.

33

&c. they set the Number 1 to the said Days. And in the like manner, observing that, in the second Year of this Cycle, the New Moons fell on *January 12th, February 10th, March 12th, &c.* to the said Days they set the Number 2. And after this Method they went through all the nineteen Years of this Cycle; as may be seen (||) in the Calendar adjoyning to the End of this Chronological Treatise. The Numbers thus set to the Days, whereon the New Moons fell in each Year, are called the *Golden Numbers*, either because they were formerly wont to be writ in Gold, or else because of their Golden or Great Use. Any one of these Golden Numbers is otherwise called the (*) *Prime*, because the said Numbers were placed in the Prime or First Column of the Calendar, as they still are in our Church Calendar, and in the Calendar adjoyning to this Treatise : Or else

(||) As also in the Calendar of the Common Prayer-Book.

(*) It is called by this Name in the Directions belonging to the *Table for finding Easter for ever* in the Common-Prayer Book.

because

Of the Cycle of the Moon,

because each Golden Number denotes *Luna Prima*, or the First Day of the New Moon, according to which way of speaking the Full Moon is frequently styl'd *Luna Quartadecima*, as falling on the Fourteenth day after the New Moon inclusively. The Golden Numbers being thus placed, it was easy to find, what Day of any Month in any Year given the New Moon would fall upon, it being known to what Year of the Moon's Cycle the Year given answered. Thus suppose, A. D. 354, to be the Year given, which answers to the 13th year of the Moon's Cycle; and suppose it be enquired, what day of *March* the New Moon fell upon that Year, I look for the Number 13 in the Month of *March*, and find it set to the 11th Day; whereby is shewn, that the New Moon fell that Year on that Day of *March*.

5.
How to
find the
New
Moons at
present by
the Golden
Number.

And by this Method the New Moons could be found with Accuracy enough at the Time of the *Nicene Council*, forasmuch as the Golden Number did then shew the Day (*i. e.* the *Nuchthemeron*) within which the New Moon fell out. And hereupon
is

Of the Cycle of the Moon.

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is founded the *Rule of the Nicene Council* for finding *Easter*, of which more in Chapter 7th. It is here to be observed, that the *Golden Numbers* do not now shew the *Days*, whereon the *New Moons* fall. For the *Cycle of the Moon* is less than nineteen *Julian Years*, by 1 Hour, 27 Minutes, and almost 32 Seconds. Whence it comes to pass, that, although the *New Moons* fall again upon the same *Days*, as they did nineteen years afore, yet they fall not on the same *Hour* of the Day or *Nuchthemeron*; but 1 Hour, 27 Minutes, and almost 32" Sooner. And this Difference arising in about 312 years to a whole Day, hence the *New Moons* after every 312 Years fall a whole Day (*i. e. Nuchthemeron*) sooner. Upon this Score the *New Moons* fall now four Days sooner, than they did at the Time of the *Nicene Council*. Which being observed, the Day (*i. e. the Nuchthemeron*, though not the Hour of it) on which the *New Moons* fall, may be now found by the *Golden Number*. For Instance, I would know on what Day of *January* the *New Moon* will fall next Year, *viz.*

1712.

Of the Cycle of the Moon.

1712. This, by the Rule delivered in the following Paragraph, will be found to be the third year of the Moon's Cycle. I look therefore for the Golden Number 3, and find it (in the Calendar) placed to *January* the 1st, and again to *January* the 31st, so that about the Time of the *Nicene Council*, there were two New Moons in the Month of *January*, every third year of the Moon's Cycle. Whereas, according to the fore-mentioned Observations, each of the said two New Moons falling now four Days sooner, the first of them falls upon *December* 28th of this present Year, 1711; and only the other falls in the *January* following, viz. on *January* 27th, 1712.

6. It remains now to shew, how it is to be found, what Year of the Moon's Cycle any given year of Christ answers to. And this is done by (+) adding 1 to the given Year of Christ, and then dividing the Sum by 19. If 19 just divides the Number of the Year given, then it is the 19th or last Year of the Moon's Cycle; if 19

To find what Year of the Moon's Cycle any given Year of Christ answers to.

(+) The Reason of adding 1 is, because the *Æra* of Christ began in the second Year of this Cycle.

does

Of the Epacts of the Moon.

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does not just divide the said Number, but somewhat of the said Number remains over, then the said Remainder shews the Year of the Moon's Cycle. For instance, I would know to what Year of the Moon's Cycle A. D. 1712 answers. And by this Rule I find it to answer to the third Year of the Cycle; for $1712 + 1$ being divided by 19, there will remain 3. And thus much for the Cycle of the Moon.

Come we next to the Epacts of the Moon. It has been afore observed, ^{7.} *of the Epacts of the Moon.* that the Civil Lunar Year is eleven Days shorter than the Civil Solar Year. Consequently, two such Lunar years will be twenty two Days shorter than two such Solar years; and three Lunar Years will be shorter than three Solar Years by thirty-three Days. Now such as use the fixed Lunar (otherwise called the Luni-Solar Year, in order to adjust the said Lunar Year to the Solar, as often as the Lunar Year does thus come to be thirty three Days shorter than the Solar, do intercalate a Month of thirty Days into the Lunar Year; except only every 19th Year (*viz.*) the last year of the Moon's Cycle) when the intercalated

O

Of the Cycle of the Moon.

lated Month consists but of twenty-nine Days.

Golden Number.	Epacts.
1	. . XI.
2	. . XXII.
3	 III.
4	. . XIV.
5	. . XXIV.
6	. . VI.
7	. . XVII.
8	. . XVIII.
9	. . IX.
10	. . XX.
11	. . I.
12	. . XII.
13	. . XXIII.
14	. . IV.
15	. . XV.
16	. . XXVI.
17	. . VII.
18	. . XVIII.
19	. . XXIX.

By this means the Civil Lunar and Solar Years are kept so adjusted together, as that the first Year of the MOON's Cycle comes not shorter of the Solar Year than eleven Days; the second Year of the said Cycle not shorter than twenty two Days; the third year shorter only by three days,

Ec. as may be seen in the adjoyning Table. Namely, as the New Moons are are the same (*i. e.* fall on the same Day every nineteen years, so the difference between the Lunar and Solar Year is the same every nineteen Years. And because the said Difference is always to be added to the Lunar Year, in order to adjust or make it equal to the Solar Year; hence the said difference respectively belonging to each Year of the Moon's Cycle, is called the *Epact* of

Of the Epact of the Moon.

39

of the said Year, *i. e.* the Number to be *added* to the said Year to make it equal to the solar Year.

Upon this mutual Respect between the Cycle of the Moon, and the Cycle of the Epacts, there is founded this Rule for (||) finding the Epact belonging to any Year of the Moon's Cycle. Multiply the year given of the Moon's Cycle into 11; if the Product be less than 30, it is the Epact sought; if the Product be greater than 30, divide it by 30; and the Remainder of the Dividend is the Epact. *Ex. gr.* I would know the Epact for A. D. 1712, which has been already found to be the third Year of the Moon's Cycle. Wherefore three is the Epact for A. D. 1712: for $11 \times 3 = 33$, and 33 being divided by 30, there is left three of the Dividend for the Epact.

8.

How to find the Epacts of the Moon according to the Julian Account.

(||) Namely in respect of the *Julian* Account. For in respect of the *Gregorian* Account there is a different Method, the Epact being different. However, the *Julian Epact* being known, it is easy thence to know the *Gregorian Epact*. Namely, if the *Julian Epact* be greater than 11, Subtract 11 from it: it lets, add 30 to it, and out of the Sum Subtract 11, and the Residue will be the *Gregorian Epact*. For instance; it has been found, that Three is the *Julian Epact* for A. D. 1712. Wherefore $3 + 30 = 33$, and $33 - 11 = 22$, which last Number (*viz.* 22.) is the *Gregorian Epact* for the said Year, 1712.

Of the Epacts of the Moon.

9. By the Help of the Epact may be found, what Day of any Month in any Year the New Moon falls on, thus: To the Number of the Month from *March* inclusively, add the Epact of the Year given; if the Sum be less than 30, Subtract it out of 30; if greater, Subtract it out of 60; and the Remainder will be the Day, whereon the New Moon will fall. N. B. If the New Moon be sought for the Month of *January* or *March*, then nothing is to be added to the Epact; if for *February* or *April*, then only 1 is to be added. Ex. gr. I would know what Day of *December* the New Moon will fall on this A. D. 1711, the Epact whereof is 22. By the aforesaid Rule, I find it will be *December 28th*, for $22 + 10 = 32$, and $60 - 32 = 28$.

10. The Day, whereon the New Moon falls, being thus found, it is easy from thence to infer, what the Age of the Moon is on any Day given. However, there is a peculiar Rule commonly made use of to this purpose, which is this: Add the Epact of the Year, the Number of the Month from *March* inclusively, and the given Day of the Month all into one Sum: which

Of the Epacts.

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which, if it be less than 30, shews the Age of the Moon; if it be greater than 30, divide it by 30, and the Remainder of the Dividend shews the Age of the Moon, or how many Days it is from the last New Moon. And this Method wil never err a whole Day. For instance, I would know, what will be the Age of the Moon on *December 31st* of this Year 1711. By this Rule I find, that the Moon will then be three Days Old, *i. e.* that it will then be three Days from the last New Moon. For $22 + 10 = 32 = 63$, and 63 being divided by 30, there will remain of the Dividend 3. And this exactly agrees to the other foregoing Rule, whereby it was found, that the New Moon will fall on *December 28th* of this Year 1711.

It remains only to observe, that the Epacts of the Moon are justly to be esteemed as (*) Natural Characters of Time; forasmuch as they depend on a Natural Cause, *viz.* the Motion of the Moon. For the Reason, why

II.
The Epacts
of the Moon
are to be
esteemed
Natural
Characters

(*) This is insisted upon, because the Epacts are by some esteemed, not *Natural*, but *instituted* Characters.

Of the Epacts.

the Civil Lunar Year is less than the Civil Solar (*i. e. Julian*) Year by eleven Days, is, because as the Moon goes round her *Orbit*, there are twelve Conjunctions of her and the Sun, (or twelve Synodical Months, which make up a Lunar Year) in less Time by eleven Days very nearly, than the Sun seems to go once round the Ecliptick. And in like manner, the Reason why the Cycle of the Epacts, as well as that of the Moon, consists of nineteen Years, is, because in that Interval of Time, the Moon's Motion has (much) the same Respect to the Sun, as it had nineteen Years afore. And thus much for the *Natural* Characters of Time.

C H A P. IV.

Of the Cycle of the Sunday-Letter, commonly called the Cycle of the Sun.

THE Cycle of the Sun is very im-
properly so called, forasmuch as
it relates not to the Course of the Sun,
but to the Course of the Dominical
or Sunday Letter; whence it ought to
be called the Cycle of the Sunday-Letter.
It consist of twenty eight Years, for-
asmuch as after every twenty eight
Years, the Course or Order of the
Sunday-Letter is the same, as it was
afore.

1.

*The Cycle
of the Sun
improper-
ly so called.*

The Use of this Cycle arises from
(*) the Custom of Assigning in the
Calendar to each Day of the Week,
one of the first seven Letters of the
Alphabet; A being always affixed to

2.

*Of the Use
of this Cy-
cle.*

(*) This Custom being Arbitrary, hence this Cycle
is not a Natural Character, but of Humane Institution.

Of the Cycle of the Sun.

January 1st, whatever Day of the Week it be; B to January 2^d, C to January 3^d; and so in order G to January 7th. After which the same Letters are repeated again, A being affixed to January 8th, &c. According to this Method, there being 52 Weeks in a Year, the said seven Letters are repeated 52 Times in the Calendar. And were there but just 52 Weeks, the Letter G would belong to the last Day of the Year, as the Letter A does to the first; and consequently, that Letter, which was at first constituted the *Sunday-Letter*, (and the same is to be understood of the other Days of the Week) would always have been so; and there would have been no Change of the *Sunday-Letter*. But our Year consisting of 52 Weeks, and an odd Day over, hence it comes to pass, that the Letter A belongs to the last, as well as to the first Day of every Year. For, although every Leap-Year consists of 366 Days, and so of two Days over 52 Weeks, yet it is not usual to add a Letter more, *viz.* B, to the End of the Year; but instead thereof to repeat the Letter F. which

which (†) answers to the 24th of *February*, and to affix it again to the intercalated Day (as has been (*) afore observed) which we call *February 25th*. By which means the said seven Letters of the Alphabet remain affixed to the same Days of a Leap-Year, as of a Common Year, through all the rest of the Calendar, both before and after. The Letter *A* then thus always belonging to the first and last Day of the same Year, and consequently to the last Day of the Old Year, and first Day of the New ; it thence comes to pass, that there is a Change made as to the *Sunday-Letter* in a backward Order, that is, supposing *G* to be the *Sunday-Letter* one Year, *F* will be the next, and so on : which is illustrated by the following Table ; where it must be observed, that the great Letter is the *Sunday-Letter* for each Year.

(†) As may be seen in the Calendar adjoined to the End of this Treatise.

(*) Chap. 2. §. 17.

Of the Cycle of the Sun.

December 1711.

a 24	Monday
b 25	Tuesday
c 26	Wednesday
d 27	Thursday
e 28	Friday
f 29	Saturday
G 30	Sunday
a 31	Monday

January 1712.

a 1	Tuesday
b 2	Wednesday
c 3	Thursday
d 4	Friday
e 5	Saturday
f 6	Sunday
g 7	Monday
a 8	Tuesday

3.
The Odd
Day in
every Com-
mon Year
makes a
single
Change in
the Sun-
day-Let-
ter.

As from the foregoing Table it is evident, how the odd Day above 52 Weeks in a Year does make the *Sunday-Letter* change from one Letter to the next to it in a backward Order; so it is obvious, that were there but this single Change, *Sunday* would be denoted by each of the seven Letters every seven Years, and so the Cycle of the *Sunday-Letter* would consist of no more than seven Years. But now there being in every fourth or Leap-Year two Days above 52 Weeks, hence it comes to pass, that there is every such Year a double Change made as to the *Sunday-Letter*. Namely, as the odd single Day above 52 Weeks in a common Year, makes (as has been shewn by the foregoing Table) the first *Sunday* in *January* to shift from that which was the *Sunday Letter* of the foregoing Year, to the next Letter

Of the Cycle of the Sun.

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Letter to it in a backward Order ; so the other Day, intercalated every Leap-Year after the 23d of *February*, (though it makes no Change as to the Days of the *Month*, to which the Alphabetical Letters respectively belong ; which is brought about by the Artifice of repeating the Letter *F* twice, as was afore observed ; yet it) does make a Change as to the Days of the *Week*, to which each Alphabetical Letter is to belong for the remaining Part of the Year ; as is evident by the following Table containing the latter Part of *February* 1712, being Leap-Year, and the former Part of *March*.

February.

23				<i>Saturday</i>
24		F		<i>Sunday</i>
25		f		<i>Monday</i>
26		g		<i>Tuesday</i>
27		a		<i>Wednesday</i>
28		b		<i>Thursday</i>
29		c		<i>Friday</i>

March.

1		d		<i>Saturday</i>
2		E		<i>Sunday</i>
3		f		<i>Monday</i>
4		g		<i>Tuesday</i>
5		a		<i>Wednesday</i>
6		b		<i>Thursday</i>
7		c		<i>Friday</i>

As the former Table shewed, how 4.
it comes to pass, that G is the *Sunday-Letter* for 1711, and F for 1712, at the Beginning of the said Year, even to *February* 23d ; so this latter Table shews

The intercalated Day makes a double Change in the Sun-

day-Letter
every
Leap-Year. shews, how it comes to pass, that after *February 23d*, not *F* as afore, but *E* is the *Sunday-Letter* for the Rest of the Year. And consequently as the former Table will serve to shew, how by the odd Day in a common Year, there is made every common Year a *single Change* as to the *Sunday-Letter*; so the latter Table, compared with the former, will shew how by the intercalated Day of a Leap-Year there is made after *February 23d*, in every Leap-Year another Change of the *Sunday-Letter*, besides the former made at the Beginning of the said Leap-Year; and consequently how there comes a *double Change* of the *Sunday-Letter* every Leap-Year.

5. Now as the Cycle of the *Sunday-Letter* would have consisted but of seven Years, had there been only a single Change of the said Letter; so, by Reason of there being a double Change of the said Letter every Leap or fourth Year, it comes to pass, that the said Cycle consists of four Times seven Years, *i. e.* the *Sunday-Letter* does not proceed in the same Course as it did afore, under twenty-eight Years; and after that Number of Years

This Cycle
why con-
sists of
twenty-
eight
Years.

Of the Cycle of the Sun.

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Years its Course or Order is the same as it was afore. Which is illustrated by the following Table; where it is to be observed, that the first Year, and every fourth Year after, of the Cycle is a Leap-Year, and therefore has two *Sunday-Letters* appertaining to it.

A TABLE of the Cycle of the Sun.

1	GF	5	BA	9	DC	13	FE	17	AG	21	CB	25	ED
2	E	6	G	10	B	14	D	18	F	22	A	26	C
3	D	7	F	11	A	15	C	19	E	23	G	27	B
4	C	8	E	12	G	16	B	20	D	24	F	28	A

To find what Year of this Cycle any given Year of our Lord answers to, and consequently, what is the *Sunday Letter* for the Year given, work thus: To the Year of our Lord given (||) add 9, and divide the Sum by 28. If

6.

To find the Cycle of the Sun for any given Year of Christ.

(||) The Reason of adding 9, is because the *Æra* of Christ began in the Tenth Year of this Cycle.

any

Of the Cycle of the Sun.

any of the Dividend remains, the said Remainder shews the Year of the Cycle sought; if nothing remains of the Dividend, then it is the last or 28th Year of the Cycle. For Instance, I would know, what Year of the Cycle of the Sun, A. D. 1712 answers to. By the foregoing Rule I find it to answer to the 13th Year of the said Cycle; (for $1712 \div 9 = 1721$, and 1721 being divided by 28, there will be left 13;) and by the Table of this Cycle I find the *Sunday-Letters* for the said Year, being a Leap-Year, to be FE, viz. F from the Beginning of *January* to *February 23d*, and after that E for the Rest of the Year, according to the (*) *Julian Account*.

7. To find, what Day of the Week the first Day of any Month falls upon. It may not be altogether unuseful to observe further, that each of the first seven Alphabetical Letters always (as is afore noted) belonging to the same Day of each Month in the Year, hence the two following *English Verses*

(*) Having found the *Sunday-Letter* according to the *Julian Account*, the *Gregorian Sunday Letter* will be the third in a backward Order from the *Julian*. Thus FE being the *Julian Sunday-Letters* for 1712, being Leap-Year, CB will be the *Gregorian Sunday-Letters* for the same.

shew

Of the Cycle of the Sun.

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shew by the first Letter of each Word, what Letter belongs to the *first* Day of each Month; the Order of the Words answering to the Order of the Months thus :

Jan. Feb. March, April, May, June,
At Dover Dwells George Brown Esquire,
July, Aug. Sept. Oct. Nov. Dec.
Good Christian Faith, And Doctor Fryar.

Wherefore the *Sunday Letter* being known, it is easy by the Help of the foregoing Verses to tell, what Day of the *Week* the first Day of any Month falls upon; namely, by considering the *Order* or *Distance* of the Letter belonging to the first Day of the given Month from the given *Sunday-Letter*. *Ex. gr.* I would know, what Day of the *Week* the first of *February* 1712 will be, when the *Sunday Letter* will be (at that Part of the said Year) *F*. By the foregoing Verses I know *D* is the Letter belonging to *February* 1st, and therefore *F* being the *Sunday-Letter*, *D*. (as being two in the Alphabetical Order before *F*) must denote *Friday*, which is agreeably two Days before *Sunday*.

In

Of the Cycle of the Sun.

In like manner, if it be enquired, what Day of the Week *March 1st*, will fall upon in 1712, when the *Sunday-Letter* will be changed from *F* to *E*. It being known by the foregoing Verses, that *D*. is the Letter that belongs also to the first of *March*, it follows that, as *D* is the Letter next before *E*, so *March 1st* must fall on (that Day of the Week which is next before *Sunday*, viz.) *Saturday*.

8. To find what Day of the Week any other Day of the Month (besides the first) falls upon.

It being thus to be known, what Day of the Week the *first* Day of any Month falls upon; thereby may be easily known also, what Day of the Week any other Day of the same Month falls upon; namely, by considering, that the 1st, 8th, 15th, 22d, and 29th Day of any Month always fall upon the same Day of the Week; and then reckoning, how far distant the Day proposed is from any of the aforesaid Days. For instance, I would know, what Day of the Week *March 18th* falls upon next Year, viz. 1712. It being afore known, that the first Day of *March* will then fall on *Saturday*, it follows, that *March 15th* will be likewise on *Saturday*; and therefore *March 18th* (as being three Days after

[Of the Cycle of the Sun.

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after *March 15th*) will fall on *Tuesday*, as being three Days after *Saturday*. And therefore, by the *Sunday-Letter* and the foregoing Verses, may be found, what Day of the *Week* any Day of the *Year* in general will fall upon. And thus we have largely shewn the Use of the Cycle of the Sun, or of the *Sunday-Letter*.

P C H A P.

C H A P. V.

Of the Indiction, and Julian Period.

I.
Of the
Indiction.

THE Indiction is a Cycle of fifteen Years, which has no Relation to any Celestial Motion, but was instituted wholly on a Political or Civil Account, *viz.* in respect to certain Taxes (as is the most received Opinion) which were to be paid every fifteen Years. When this Cycle was first instituted, is not left upon Record; but it is evident from History, that it has been in Use ever since the Time of *Constantine* the Great, or from A. D. 312. It was used both by the *Greeks* and *Romans*, but after (†) a manner somewhat different. The *Roman* Indiction is still used by the *Pope* in his Bulls, &c. And the Year of the *Roman* Indiction answer-

(†) The *Greek* Indiction begins from the first of September, the *Roman* Indiction from the first of January. And the former is used in the *Acts* of Councils, and the *Novels* of the Emperors.

ring to any given Year of Christ is found, by (||) adding 3 to the given Year of Christ, and dividing the Sum by 15. The Remainder of the Dividend, if any there be, shews the Indiction; if nothing remains, then it is the 15th or last Year of the Indiction. The principal Reason of taking Notice of this Cycle in this Treatise, is because it conduces to the Understanding of the *Julian Period*, of which we shall speak next.

The *Julian Period* is no other than a greater Cycle, made up of the three fore-mentioned Cycles of the Moon, Sun, and Indiction, multiplied one into the other, and so consisting of 7980 Years. For the Cycles of the Moon and Sun, viz. 19. and 28, being multiplied together make (*) 532; which being multiplied again by 15, the Cycle of the Indiction, makes 7980,

2.
Of the Ju-
lian Pe-
riod.

(||) The Reason of adding 3, is, because A. D. 1. began in the fourth Year of the said *Roman Indiction*.

(*) This Number of Years, arising from the Cycles of the Moon and Sun being multiplied together, is peculiarly stiled the *Dionysian Period*, and also the *Victorian Period*, from Persons of the like Names, who introduced the Use thereof.

Of the Julian Period.

the Space of the *Julian Period*. It is called the *Julian Period*, because it was adapted by the Author or Inventor of it *Joseph Scaliger*, to the *Julian Year*, and its fore-mentioned Cycles. It is of excellent Use in Chronology, or Distinguishing of Times; because the same Years of the Cycles of the Moon, Sun, and Indiction, which belong to any one Year of this *Julian Period*, will never fall together again till after 7980 Years, and consequently not as long as the World stands, according to the Opinion probably received concerning (†) the Duration of the World. And as this Period will probably not expire before the *End* of the World, and thereby consequently may be distinguished the Times of all *Future* Events; so it extends backwards (||) before the *Begin-*

(†) Namely, That it shall endure but 6000 Years. Of which about 4000 Years being expired before our Saviour's Nativity, and somewhat above 1700 Years being expired since, there remains but about 300 Years more for the World to last, according to the said Opinion.

(||) Namely, *Julian Period* 4714, answering to A. D. 1. and our Saviour being Born but about the 4000th Year of the World, it thence follows, that the *Julian Period* must be conceived to commence or begin about 700 Years before the Creation.

ning

ning of the World, and thereby consequently may be distinguished the Times of all *Past* Events from the very Creation. Hence Chronologers do endeavour to adjust all other Accounts of Time, and consequently all Transactions and Events recorded in History, to the *Julian Period*.

To find, what Year of the *Julian Period* any given Year of Christ answers to, work thus. To the given Year of Christ add 4713, (because so many Years of the *Julian Period* were expired before A. D. 1.) and the Sum gives the Year of the *Julian Period* sought. For instance, I would know, what Year of the *Julian Period* A. D. 1712 answers to. Now $1712 + 4713 = 6425$, the Year sought of the *Julian Period*.

3.
To find, what Year of the Julian Period answers to any given Year of Christ.

On the contrary, having the Year of the *Julian Period* given to find what A. D. answers thereto, work thus. From the Year of the *Julian Period* given, subtract 4713, (for the Reason above-mentioned,) and the Residue will be the A. D. sought. For instance, I would know, what A. D. answers to the *Julian Period* 6425.

4.
To find what Year of Christ answers to any given Year of the Julian Period.

P 3

Wherefore

Of the Julian Period.

Wherefore $6425 - 4713 = 1712$, the A. D. sought.

5. To find, what Year before Christ answers to any given Year of the Julian Period, less than 4714. If the Year of the *Julian Period* given be 4713, or less than it, then Subtract the same from 4714, (which is the Year of the *Julian Period*, that answers to A. D. 1.) and the Residue will shew, how long afore (the Beginning of the common Computation from the Nativity of) Christ the given Year of the *Julian Period* was. For instance, the City of *Rome* is said to have been built, J. P. 3960. I would know therefore, how long it was built before Christ. Now $4714 - 3960 = 754$. Wherefore *Rome* was built 754 Years before (the Beginning of the common *Æra*) of Christ.

6. To find the Cycle of the Sun, Moon, or Indiction, answering to any Year of the Julian Period, To know what Year of the Cycle of the Sun, Moon, or Indiction, answers to any Year given of the *Julian Period*; divide the given Year respectively by 28, or 19, or 15. The Remainder of the first Division will shew the Year of the Sun's Cycle; the Remainder of the second Division will shew the Year of the Moon's Cycle; and of the third Division, the Year of the Indiction. If nothing remains in each Division, then it is the last

Of the Julian Period.

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last Year of each Cycle respectively.

On the contrary to know, what 7.
Year of the *Julian Period* answers to And the
contrary.
any given Year of the Cycle of the
Sun, or Moon, or Indiction; multi-
ply the Cycle of the Sun into 4845,
the Cycle of the Moon into 4200,
the Cycle of the Indiction into 6916.
The Sum of the Products being divi-
ded by 7980, the Remainder will
shew the Year of the *Julian Period*
sought.

And thus we have gone through 8.
the several Characters of Time, whose Cycles and
Periods,
why so cal-
led.
Computation after a certain Number
of Years begins anew; whence each
of them is stiled, either a *Cycle*, as the
Cycle of the Sun, Moon, and Indicti-
on; or a *Period*, as the *Julian Pe-
riod*.

C H A P. VI.

Of Epoch's or Æra's ; and especially of the Æra or Year of Christ, the Æra of the Olympiads, and the Æra of the Building of Rome.

1.
*Of Epoch's
or Æras.*

WE are now to speak of those Characters of Time, whose Computation does not begin a-new after a certain Number of Years, but is still continued on further and further from their respective Heads or single Beginnings. And these are distinguished from the circular Characters of Time already described, by the Name of (*) *Epoch's* or *Æra's*.

2.
*Of the
Æra of
Christ,
used by Us
and other
Christians.*

There are several *Epoch's* or *Æra's* made use of, both formerly and at present, in the several Parts of the

(*) These Words are frequently used promiscuously. Some take an *Æra* to denote properly any continued Computation, and an *Epoch* to signify properly the Beginning of the said Computation ; the Greek Word ἐποχή denoting (as it were) a Pause or Stop in Time, from whence Time is computed. As to the Etymology of *Æra*, there is no good Account of it.

World.

World. That of principal Concern to us Christians is the *Æra* of *Christ*, or the common Way of computing Time from the Nativity of Christ; according to which this present Year is reckoned the 1711th from the *Nativity* of Christ, or rather from the *first of January* next following the Nativity of Christ, according to the common Computation generally receiv'd in *Christendom*, or *Europe*. The *Æra* or Way of Reckoning from *Christ*, was first introduced by one *Dionysius*, surnamed (†) *Exiguus*, somewhat more than 500 Years after Christ: Since which Time Christians have reckoned their Years, either from the Birth or Incarnation of our Blessed Saviour; whereas before they were wont to reckon some other Ways. According to *Dionysius*, the Author of the *Æra* computed from Christ our Lord, was conceived on the 8th of the Calends of *April* (now called *Lady-Day*) in the first Year of this *Æra*; and was Born about the then Winter-Solstice next following; that is, *Decemb. 25*. And this Account was at first univer-

(†) He was so surnamed from his little Stature.

Of the Year of Christ.

fully received among Christians ; but is now a-days used only in *England* and *Ireland*, where not only the Ecclesiastical, but also the Civil Year, is still reckoned according to Law, from the *Feast of the Anunciation*, or *Lady-Day*, as it was at first by *Dionysius* himself. Whereas in other Parts of *Christendom*, as is afore observ'd, and even in *England* as to common Affairs which require not a Legal (Ecclesiastical or Civil) Date, the Year of Christ is reckoned now a-days, not from the *Annunciation* or *Lady-Day*, but from the *First of January* next before the *Lady-Day* from which the Legal Date of our Ecclesiastical or Civil Year begins. It is also to be observ'd, that the Common Account by *A. D.* introduced by the foresaid *Dionysius Exiguus* does not agree exactly to the *True Years of Christ's Age*. Forasmuch as according is ereto, *Herod the Great* must be Dead before our Saviour was Born, which is contrary to the Gospel History. How much the Difference between the True and Common Account is, the Learned are not agreed. But I refer that Opinion, which makes the common Account

Of the Year of the World. 63

count *too little* by *two* Years. So that whereas this present Year is *Commonly* esteem'd *A. D.* 1711, yet is *Truly A. D.* 1713, or the 1713th Year from the *Birth of Christ* or *January 1.* next ensuing.

There is also another *Æra* frequently made Use of by Christian Writers, namely, the *Æra* of the *Creation*, which is generally agreed to have been about 4000 Years before Christ. And because to say such or such a Thing fell out in such a Year of the *World*, does not give us so clear an Idea of the Distance of the said Occurrence from us, as it does to say, that it happened in such or such a Year *before Christ*; therefore, the Computation from the *Creation* of the *World* begins to be laid aside, even in Matters relating to the Sacred History of the Old Testament, and instead thereof the Occurrences of the Old Testament are now a-days computed by their Distance *before Christ*. Thus instead of saying, that the *Universal Deluge* happened *A. M.* or in the Year of the *World*, 1656, it is thought more Instructive to say, that it happened 2294 Years *before Christ*, this last

3.
Of the
Æra of the
World, or
Creation.

last Manner of Computation giving us a clearer Notion of the Time when the Flood happened in respect of its Distance from us. For we being wont to reckon our Time *from Christ*, and so reckoning this present Year to be the 1711th from Christ; when we are told, that the Flood was 2294 *before* Christ, we can from thence easily gather, that the Flood was about 4000 Years ago in respect of this present Time. And on the same Considerations, it appears to be much the best or easiest and clearest Way for us, to compute likewise all Occurrences, mentioned in any other as well as the Sacred History, by their Distance either *before* or *after* Christ; and so to make the *Nativity of Christ* the Universal *Head* or *Epoch* of all Chronology, counting therefrom all Occurrences either *Backward* or *Forward*.

4.
Of the
Æra of the
Olympi-
piads.

The most Antient and Renowned *Epoch* used by the Heathens is that of the *Olympiads* or *Olympick Games*, which were instituted by one *Iphitus*, in the Fields of *Olympia*, a City or Town of the Region *Elis* in the *Peloponnese*; and which lasted five Days, the last whereof fell on the Full Moon, which was next after the Summer Solstice.

Of the Olympiads.

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stice. These Games were celebrated every four Years, *that is*, there were three Years between the Years wherein the next preceding and the next following *Olympiad* was celebrated. Hence by a compleat *Olympiad*, is denoted the Space of four Years; the Year wherein the *Olympiad* was celebrated, being stiled the first Year of the said *Olympiad*, and so on. The Celebration of the first *Olympiad* is referred to the 3938th Year of the *Julian Period*; and consequently to the 777th Year *before Christ*, viz. to the Calends of *July*, in the Summer of the said Years. Wherefore,

Any Year of the *Olympiads* being given, to find the correspondent Year of the *Julian Period*, work thus; Multiply the compleat *Olympiads* by 4, and to the Product add the Year (if it be given) of the *Olympiad* running, and also 3937, the Sum is the Year of the *Julian Period* sought. For Instance, *Rome* is said to be built, according to *Varro's* Account, in the fourth Year of the sixth *Olympiad*. Wherefore I multiply 5 (the Number of the compleat *Olympiads*) by 4, which makes 20, and thereto I add 4 more, (the Year given of the *Olympiad*)

5.

To find the Year of the Julian Period answering to any Year of the Olympiads.

piad running, or 6th Olympiad,) and also 3937. All which together amounts to 3961, the Year sought of the *Julian Period*.

6.

And thereby to find the correspondent Year of Christ.

Having found the Year of the *Julian Period* answering to any given Year of the *Olympiads*, thereby may also be found the correspondent Year (respectively) before or after Christ. Namely, if the Year found of the *Julian Period* be less than 4713, then subtract the same from 4713, and the Remainder will shew the correspondent Year *before* Christ: But if the Year found of the *Julian Period* be greater than 4713, then subtract 4713 from it, and the Remainder will shew the correspondent Year *after* Christ. Thus, it being found, that Rome was built in *Julian Period* 3961, I subtract 3961 from 4713, and there remains 752, the correspondent Year *before* Christ, wherein Rome was built.

7.

Another Way to find the Year of Christ answering to any Olympick Year.

But if there be no Occasion to find the correspondent Year of the *Julian Period*, the Year before or after Christ, respectively answering to any given Year of the *Olympiads* may be found thus. Multiply (as afore) the compleat *Olympiads* by 4, and to the Product

duct add the Year given (if any be specified) of the *Olympiad* running. This Sum, if it be less than 776, subtract it from 776, and the Remainder will shew the correspondent Year *before* Christ: but if the Sum be greater than 776, then subtract 776 from it, and the Remainder will shew the correspondent Year *after* Christ. Thus I would know what Year of Christ answers to the fourth Year of the sixth *Olympiad*, wherein *Rome* was built according to *Varro*. Wherefore, (as afore) $5 \times 4 = 20$, and $20 + 4 = 24$. Which Sum being less than 776, I subtract it from 776, and there will remain 752, the correspondent Year *before* Christ, as was found before by the other Method.

Any Year of the *Julian Period* being given, to find what *Olympick* Year answers thereto, work thus: From the Year given subtract 3937, and divide the Remainder by 4, the Quotient will shew the compleat *Olympiads*, and the Fraction or Remainder of the Dividend will shew the Year of the *Olympiad* running. If there be no such Remainder, then it is the last or fourth Year of the *Olympiad* running. *Ex. gr.* I would know, what *Olympick*

8.
To find,
what
Olympick
Year an-
swers to
any given
Year of the
Julian Pe-
riod.

Of the Computation

pick Year answers to J. P. 3961. From 3961, I subtract 3937, and there remains 24; which divided by 4, gives 6 in the Quotient, and leaves no Fraction of the Dividend. Wherefore the *Olympick* Year sought, is the fourth Year of the sixth *Olympiad*.

9.
Of the
Æra of
U. C. or
the Building of
Rome.

As the Account by the *Olympiads* was, the principal *Æra* among the *Greeks*; so the principal *Æra* among the *Romans* was, that of the (||) *U. C.* or *Building of Rome*; which, according to *Varro* began *Julian Period*, 3961, but according to the *Fasti Capitolini* in the following Year, viz. *Julian Period* 3962. Wherefore

10.
To find the
Year of the
Julian Period an-
swering to
any given
Year of
U. C.

Any Year of *U. C.* being given, add thereto 3960, and you'll have the correspondent Year of the *Julian Period*, according to *Varro's* Account; or add 3961, and you'll have the correspondent Year of the *Julian Period*, according to the *Capitoline* Account.

On the contrary, from the given Year of *Julian Period*, subtract 3960, and the Residue will give the Year of *U. C.* according to *Varro*; or sub-

(||) *U. C.* are the Initial Letters of *Urbs Condita*, and so are put to denote in short the *Building of the City*, viz. *Rome*.

from the Building of Rome.

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tract 3961, and the Residue will be the Year of U. C. according to the *Capitoline* Account.

Forasmuch as *Rome* is computed to 11.
have been built 752 Years before *Christ*; therefore from 752 subtract To find the Year before or after Christ, answering to any given Year of U. C.
any given Year of U. C. less than the same, and the Residue will shew the correspondent Year *before Christ*: Or if the Year given of U. C. be greater than 752, then subtract 752 from it, and the Residue will shew the correspondent Year *after Christ*. Thus the Regal State of *Rome* is computed to have ended in U. C. 245, to which answers the Year 507 *before Christ*: for $752 - 245 = 507$. And the Removal of the Imperial Seat from *Rome* to *Constantinople* by *Constantine* the Great, is computed to have happened U. C. 1084, and so 332 Years *after Christ*: for $1084 - 752 = 332$.

As for other *Epoch's* or *Æra's*, they 12.
being of less Note and Use to us, it of other Epoch's or Æra's.
will be sufficient to shew in short, how long before or after *Christ* each of them began.

Q

The

Before Christ.

The *Destruction of Troy*,
is computed to fall in with
(*) *Julian Period*, 3531,
and so the *Æra* taken
from thence to begin. } 1183.

The *Æra of Nabonassar*
King of *Babylon*, from the
Beginning of whose Reign
the *Chaldeans* and *Egypti-*
ans reckoned their Years,
began *February 26. J. P.*
3967, and consequently } 747.

The *Æra* (†) of the
Death of *Alexander* the
Great, began *Novemb. 12,*
J. P. 4390, and so } 324

(*) Herein is followed the Opinion of *Dionysius Ha-*
licarnassens, and *Diodorus Siculus*.

(†) Some distinguish between the *Alexandrian Æra*,
and the *Philippean*, making the *Philippean* (so called
from *Philip Aridæus*, Brother to *Alexander* the Great)
to begin from the Death of *Alexander*, or more exact-
ly from the 12th of *November* following the Death of
Alexander, and so *Julian Period*, 4390; and the *A-*
lexandrian to begin not till twelve Years after *Alex-*
ander's Death, viz. *October 1st*, *Julian Period*, 4402.
This latter *Æra* is esteemed by some learned Men to
be the same with the *Æra Seleucidarum*, otherwise
called *Æra Contractum*, and the Years of the Greeks in
the Books of the *Maccabees*.

The

Of Epoch's or Æra's.

71

Before Christ.

The *Æra* of the City }
Antioch, used by *Eusebius*, }
Evagrius, *Cedrenus*, &c. } 49.
 began from the Autumn }
J. P. 4665, and so }

The *Æra* of the *Julian* }
Reformation of the Calen- }
dar, began *January* 1, *J.* } 45.
P. 4669, and so }

The *Æra Actiaca*, so }
 denominated from the Vi- }
 ctory obtain' by *Augustus* } 30.
 over *Anthony* at *Actium*, }
 began *August* 29, *J. P.* }
 4684, and so }

After Christ.

The *Dioclesian Æra*, or }
Æra of the (||) Martyrs, }
 otherwise called the *Æra* } 284.
 of the *Abissinians*, began }
August 29, A. D. }

(||) So called from the Multitude of Christians that
 suffered *Martyrdom* in the *Dioclesian* Persecution.

Of Epoch's or *Æra's*.

After Christ.

The *Æra* of the *Hegira*,
or Flight of *Mahomet* from
Mecca to *Medina*, used by
the *Turks* and *Arabs*, be- } 622
gan July 16. A. D.

The *Æra* of *Yezdegird*,
or the *Persian Æra*, began } 632
July 16, A. D.

From this Table of the Beginnings of the fore-mentioned *Æra's*, it is easy to find out the Year before or after Christ, which answers to any Year given of any of the said *Æra's*, which are computed by *Julian* Years; as are the *Æra's* of the Destruction of *Troy*, of the *Julian* Reformation, of *Dioclesian*, &c. But it is more difficult to do so in respect of the *Æra* of *Nabonassar*, of *Alexander's* Death, and of the *Hegira*, because they are computed by Years different from the *Julian* Years. It will be sufficient to our present Design to observe here, that 1461 *Nabonassar* Years,

Of Epoch's or Æra's.

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Years, make only 1460 *Julian* Years;
and the same is to be understood
of the *Alexandrian* Years, as being
of the same Kind with the *Nabo-*
nassars.

Q 3

CHAP,

Of finding Easter-Day.

C H A P. VII.

Of the Method to find Easter-Day, according to the Nicene Rule, (as still followed by our Church,) by the Help of the Golden Numbers affixed to the Calendar. To which is adjoined the Roman Method of Dating, or denoting the Days of the Month.

I.
The Ni-
cene Rule
for finding
Easter
Day.

THE Rule prescribed by the Fathers of the *Nicene Council* for the finding of *Easter*, and which is still followed by the Church of *England*, is thus expressed in our *Common-Prayer-Book*: (†) *Easter-Day is always*

(†) It is observable that the *Nicene Fathers* in prescribing this Rule did not act Arbitrarily, but conformed themselves as near as the Difference of Circumstances would permit, to the Rule prescribed by God for observing the *Passover*. Namely the Rule for the *Jewish Passover* was, that it should be kept on the *Fourteenth Day*, which is much the same as on the *Full Moon* of the first Ecclesiastical Month call'd *Nisan*. And the *Nicene Rule* for *Easter* is, that it shall be kept on the *Sunday* next after the *Fourteenth Day* or *First Moon* of our First Ecclesiastical Month, or that part of our *March*, which answers to the *Jewish Month Nisan*.

the

Of finding Easter-Day.

75

the first Sunday after the first Full Moon, which happens next after the One and Twentieth Day of March. And if the Full Moon happens upon a Sunday, Easter-Day is the Sunday after.

According to this Rule, *Easter-Day* 2. may easily be found by the Help of the Golden Numbers (*) duly affixed to the Calendar, and by retaining in Memory, and applying to Practice, what has been said of the Golden Numbers, and Dominical Letter, *Chap.* 3d and 4th.

To find Easter-Day according to the said Rule, by the Help of the Golden Numbers.

For Instance, I would know, what Day *Easter-Day*, will fall upon the next Year, *viz.* 1712. In order hereto, first I enquire what is the *Golden Number* for the given Year, and I find it to be three, according to the Rule given *Chap. III. Sect. 6.* Then I enquire what is the Dominical or *Sunday Letter* for the given Year, and (according to the Rules given, *Chap. IV. Sect. 5. 6.*) I find that there will be

(*) In our old large Common Prayer-Books, great Care was taken duly to affix the Golden Numbers to their proper Days; and to that End black Lines were drawn between every Day of the Calendar. But of late Years no such Care is taken, insomuch that it is not to be known with any Certainty what Days the Golden Numbers do answer to in the Church-Calendars, of late printed without such black Lines.

Of finding Easter-Day.

two *Sunday* Letters next Year, it being Leap-Year. Of which two Letters, *viz.* *FE*, the latter *E* will be the *Sunday* Letter after *February 23^d*, and so that whereby I am to be guided in finding out *Easter-Day*.

Now because the Full Moon, on which *Easter* depends, is (according to the *Nicene* Rule) that which happens next after the *21st of March*; and because the said Full Moon is (agreeably to *Exod. 12. 6.*) to be esteemed the *14th Day* after its New Moon inclusively, (*i. e.* the Day of the said New Moon, being reckoned the first of the *14th*, and the Day of the Full Moon the last, hence the said *Easter* New Moon can never fall before the *9th of March*, nor after the *5th of April*. Wherefore I look for the Golden Number 3 between *March 9th*, and *April 5th*, and find it placed to *March 31st*, which therefore was the Day on which the *Easter* New Moon fell at the Time of the *Nicene* Council, in the 3^d Year of the Moon's Cycle: and consequently is esteemed so still by us. Wherefore the *Easter* Full Moon (being fourteen Days after inclusively) will be *April 13th*;

13th; which being shewn by the Letter E affix'd to it to be a *Sunday*, therefore, by the *Nicene Rule*, *Easter-Day* must be the *Sunday* after, viz. *April 20th*. And in like manner may *Easter Day* be found for any other given Year, by the Help of the Calendar adjoined to the End of this Chapter; and consequently Tables may be made, shewing the Day, whereon *Easter* will fall, for any Term of Years.

It remains now only to observe, 3. that in Order to render the following Calendar more useful, therein ^{Of the Roman way of Dating, or denoting the Days of the Year.} is set down the *Roman Manner of Dating*, or denoting the several Days of the Year. Where it is to be noted, that the *Roman Numbers* between the Words *Kalends*, *Nones*, *Ides* and *Calends* of the succeeding Month, do respectively refer always to the following Word. Thus the Number IV over-against *January 2^d*, refers to the following *Nones*, and denotes as much as the 4th Day of, or before the *Nones* of *January*. So XI set to *January 22^d*, denotes the 11th of, or before the *Calends* of *February*.

Wherefore any *Roman Date* given, may be turned into *our Date*, by finding

Of the Roman Date.

finding in the Calendar the Date given, (suppose 3 *Id. Februar.*) and seeing what Date of ours answers thereto, (*viz. February 11th.*) And on the other Hand any Date of ours being given, *v. g. January 31st*; it may be turned into the *Roman* Date, by finding the *Roman* Date affixed thereto, *viz. Prid. Kal. Febr.*

January

The Calendar.

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January

February.

Golden Number.	Day of Month.	Weekly Letters.	Roman Date.	Golden Number.	Day of Month.	Weekly Letters.	Roman Date.
3 . .	1	A	Calendæ		1	D	Calendæ
	2	B	IV	11 .	2	E	IV
11 . .	3	C	III	19 .	3	F	III
	4	D	Prid.	8 .	4	G	Prid.
19 .	5	E	Nonæ		5	A	Nonæ
8 . .	6	F	VIII	16 .	6	B	VIII
	7	G	VII	5 . .	7	C	VII
16 . .	8	A	VI		8	D	VI
5 . .	9	B	V	13 .	9	E	V
	10	C	IV	2 .	10	F	IV
13 . .	11	D	III		11	G	III
2 . .	12	E	Prid.	10 .	12	A	Prid.
	13	F	Idus.		13	B	Idus.
10 . .	14	G	XIX	18 .	14	C	XVI
	15	A	XVIII	7 .	15	D	XV
18 . .	16	B	XVII		16	E	XIV
7 .	17	C	XVI	15 .	17	F	XIII
	18	D	XV	4 .	18	G	XII
15 .	19	E	XIV		19	A	XI
4 .	20	F	XIII	12 .	20	B	X
	21	G	XII	1 .	21	C	IX
12 . .	22	A	XI		22	D	VIII
1 .	23	B	X	9 .	23	E	VII
	24	C	IX		24	F	VI
9 .	25	D	VIII	17 .	25	G	V
	26	E	VII	6 .	26	A	IV
17 . .	27	F	VI		27	B	III
6 .	28	G	V	14 .	28	C	Prid. Cal.
	29	A	IV				
14 .	30	B	III				
3 .	31	C	Prid. Kal.				

Golden

March.

April.

Golden Number	Day of Month.	Weekly Letters.	Roman Date.	Golden Number.	Day of Month.	Weekly Letters.	Roman Date.
3 . .	1	D	Calendæ		1	G	Calendæ
	2	E	VI	11 .	2	A	IV
11 . .	3	F	V	19 .	3	B	III
	4	G	IV	8 .	4	C	Prid.
19 . .	5	A	III		5	D	Nonæ
8 . .	6	B	Prid.	16 .	6	E	VIII
	7	C	Nonæ	5 .	7	F	VII
16 . .	8	D	VIII		8	G	VI
5 . .	9	E	VII	13 .	9	A	V
	10	F	VI	2 .	10	B	IV
13 .	11	G	V	11	11	C	III
2 .	12	A	IV	10 .	12	D	Prid.
	13	B	III		13	E	Idus.
10 . .	14	C	Prid.	18 .	14	F	XVIII
	15	D	Idus.	7 .	15	G	XVII
18 . .	16	E	XVII		16	A	XVI
7 . .	17	F	XVI	15 .	17	B	XV
	18	G	XV	4 .	18	C	XIV
15 . .	19	A	XIV		19	D	XIII
4 .	20	B	XIII	12 .	20	E	XII
	21	C	XII	1 .	21	F	XI
12 . .	22	D	XI		22	G	X
1 .	23	E	X	9 .	23	A	IX
	24	F	IX		24	B	VIII
9 . .	25	G	VIII	17 .	25	C	VII
	26	A	VII	6 .	26	D	VI
17 . .	27	B	VI		27	E	V
6 . .	28	C	V	14 .	28	F	IV
	29	D	IV	3 .	29	G	III
14 .	30	E	III		30	A	Prid. Cal
3 .	31	F	Prid. Kal.				Golden

The Calendar.

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May.					June.				
Golden Number.	Month Day of	Letters. Weekly	Roman Date.		Golden Number	Month Day of	Letters. Weekly	Roman Date.	
11 .	1	B	Calendæ			1	E	Calendæ	
	2	C	VI		19 ...	2	F	IV	
19 .	3	D	V		8 ...	3	G	III	
8 .	4	E	IV		16 ...	4	A	Prid.	
	5	F	III		5 ..	5	B	Nonæ.	
16 .	6	G	Prid.			6	C	VIII	
5 .	7	A	Nonæ.		13 ...	7	D	VII	
	8	B	VIII		2 ...	8	E	VI	
13 .	9	C	VII			9	F	V	
2 .	10	D	VI		10 ...	10	G	IV	
	11	E	V			11	A	III	
10 .	12	F	IV		18 ...	12	B	Prid.	
	13	G	III		7 ...	13	C	Idus.	
18 .	14	A	Prid.			14	D	XVIII	
	15	B	Idus.		15 ...	15	E	XVII	
7 .	16	C	XVII		4 ...	16	F	XVI	
	17	D	XVI			17	G	XV	
15 .	18	E	XV		12 ...	18	A	XIV	
4 .	19	F	XIV		1 ...	19	B	XIII	
	20	G	XIII			20	C	XII	
12 .	21	A	XII		9 ...	21	D	XI	
1 .	22	B	XI			22	E	X	
	23	C	X		17 ...	23	F	IX	
9 .	24	D	IX		6 ...	24	G	VIII	
	25	E	VIII			25	A	VII	
17 .	26	F	VII		14 ...	26	B	VI	
6 .	27	G	VI		3 ...	27	C	V	
	28	A	V			28	D	IV	
14 .	29	B	IV		11 ...	29	E	III	
3 .	30	C	III			30	F	Prid Cal.	
11 .	31	D	Prid. Kal						

Golden

July.				August.			
Golden Number.	Day of Month.	Letters Weekly	Roman Date.	Golden Number.	Day of Month.	Letters Weekly	Roman Date.
19 ..	1	G	Calendæ	8 ..	1	C	Calendæ
8 ..	2	A	VI	16 ..	2	D	IV
	3	B	V	5 ..	3	E	III
16 ..	4	C	IV		4	F	Prid.
5 ..	5	D	III	13 ..	5	G	Nonæ
	6	E	Prid.	2 .	6	A	VIII
13 ..	7	F	Nonæ		7	B	VII
2 ..	8	G	VIII	10 .	8	C	VI
	9	A	VII		9	D	V
10 ..	10	B	VI	18 .	10	E	IV
	11	C	V	7 .	11	F	III
18 ..	12	D	IV		12	G	Prid.
7 ..	13	E	III	15 .	13	A	Idus.
	14	F	Prid.	4 .	14	B	XIX
15 ..	15	G	Idus.		15	C	XVIII
4 ..	16	A	XVII	12 .	16	D	XVII
	17	B	XVI	1 .	17	E	XVI
12 ..	18	C	XV		18	F	XV
1 ..	19	D	XIV	9 .	19	G	XIV
	20	E	XIII		20	A	XIII
9 ..	21	F	XII	17 .	21	B	XII
	22	G	XI	6 .	22	C	XI
17 ..	23	A	X		23	D	X
6 ..	24	B	IX	14 .	24	E	IX
	25	C	VIII	3 .	25	F	VIII
14 .	26	D	VII		26	G	VII
3 .	27	E	VI	11 ..	27	A	VI
	28	F	V		28	B	V
11 .	29	G	IV	19 ..	29	C	IV
	30	A	III	8 ..	30	D	III
19 ..	31	B	Prid Kal		31	E	Prid Kal
							Golden

September.

October.

Golden Number.	Day of Month.	Weekly Letters.	Roman Date.	Golden Number.	Day of Month.	Weekly Letters.	Roman Date.
16 . .	1	F	Calendæ	16 .	1	A	Calendæ
5 . .	2	G	V	5 .	2	B	VI
	3	A	III	13 . .	3	C	V
13 . .	4	B	Prid.	2 .	4	D	IV
2 . .	5	C	Nonæ		5	E	III
	6	D	VIII	10 .	6	F	Prid.
10 . .	7	E	VII		7	G	Nonæ.
	8	F	VI	18 . .	8	A	VIII
18 . .	9	G	V	7 .	9	B	VII
7 .	10	A	IV		10	C	VI
	11	B	III	15 . .	11	D	V
15 .	12	C	Prid.	4 .	12	E	IV
4 .	13	D	Idus:		13	F	III
	14	E	XVIII	12 . .	14	G	Prid.
12 .	15	F	XVII	1 .	15	A	Idus.
1 . .	16	G	XVI		16	B	XVII
	17	A	XV	9 .	17	C	XVI
9 .	18	B	XIV		18	D	XV
	19	C	XIII	17 .	19	E	XIV
17 .	20	D	XII	6 .	20	F	XIII
6 .	21	E	XI		21	G	XII
	22	F	X	14 .	22	A	XI
14 .	23	G	X	3 .	23	B	X
3 .	24	A	VIII		24	C	IX
	25	B	VII	11 .	25	D	VIII
11 .	26	C	VI		26	E	VII
19 .	27	D	V	19 .	27	F	VI
	28	E	IV	8 .	28	G	V
8	29	F	III		29	A	IV
	30	G	Prid. Kal	16 .	30	B	III
				5 .	31	C	Prid Cal.

Golden

November.				December.			
Golden Number.	Day of Month.	Letters Weekly.	Roman Date.	Golden Number.	Day of Month.	Letters Weekly.	Roman Date.
	1	D	Calendæ	13 .	1	F	Calendæ
13 . .	2	E	IV	2 .	2	G	IV
2	3	F	III		3	A	III
	4	G	Prid.	10 . .	4	B	Prid.
10 .	5	A	Nonæ		5	C	Nonæ
	6	B	VIII	18 . .	6	D	VIII
18 .	7	C	VII	7 .	7	E	VII
7 .	8	D	VI		8	F	VI
	9	E	V	15 .	9	G	V
15 .	10	F	IV	4 .	10	A	IV
4 .	11	G	III		11	B	III
	12	A	Prid.	12 .	12	C	Prid.
12 .	13	B	Idus.	1 .	13	D	Idus.
1 .	14	C	XVIII		14	E	XIX
	15	D	XVII	9 .	15	F	XVIII
9 .	16	E	XVI		16	G	XVII
	17	F	XV	17 .	17	A	XVI
17 .	18	G	XIV	6 .	18	B	XV
6 . .	19	A	XIII		19	C	XIV
	20	B	XII	14 .	20	D	XIII
14 .	21	C	XI	3 .	21	E	XII
3 .	22	D	X		22	F	XI
	23	E	IX	11 .	23	G	X
11 .	24	F	VIII		24	A	IX
19 .	25	G	VII	19 .	25	B	VIII
	26	A	VI	8 .	26	C	VII
8 .	27	B	V		27	D	VI
	28	C	IV	16 .	28	E	V
16 . .	2	D	III	5 .	29	F	IV
5 .	30	E	Prid Kal		30	G	III
				13 .	31	A	Prid. Kal.
							Having

Of finding Easter-Day.

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Having shewn how to find *Easter-Day*, according to the *Julian* or *Old Account*, used by Us in *Great Britain* and *Ireland*, it may not be improper to adjoin here, by way of *Annotation*, the Method of finding *Easter-Day* according to the *Gregorian* or *New Account*, used in all Countries where the *Popish Religion* is established. Now this is done by Help of the Table here subjoined, wherein in the first Column are contained the *Gregorian Epacts*, that are now and will be in Use till 1800 exclusively; and in the second Column are set down the Days whereon falls the *Easter Full-Moon*; and in the third Column is set down the *Weekly Letter* answering to the said Days of the *Easter Full Moon*.

Epacts	Full Moons.	Letters. Weekly	Epacts.	Full Moons.	Letters. Weekly
X	13 April	E	IX	4 April	C
XI	2 April	A	XX	24 March	F
XXII	22 March	D	I	12 April	D
III	10 April	B	XII	1 April	G
XIV	30 March	E	XXIII	21 March	C
XXV	18 April	C	IV	9 April	A
VI	7 April	F	XV	29 March	D
XVII	27 March	B	XXVI	17 April	B
XXVIII	15 April	G	VII	6 April	E
			XXVIII	26 March	A

The Use of the foregoing Table is this. Having found (as is above-shewn in the Note on *Chap. 3. Sect. 8.* and *Chap. 4. Sect. 6.*) the *Gregorian Epact* and *Sunday-Letter*, over-against the said Epact in the foregoing Table is placed the Day whereon falls the *Easter Full Moon*, and thereto is affixed its respective Letter. From which therefore you are to reckon in an Alphabetical Order, till you come to the *Sunday-Letter* for that Year, and the Day of the Month answering to the said *Sunday-Letter*, is the *Gregorian Easter-Day*. Only if it happens, that the Full Moon falls on a *Sunday*,
R then

Of finding Easter-Day.

then (according to the *Nicene Rule*) the *Sunday* next following is the *Gregorian Easter-Day*. For Instance: It has been already (*viz.* in *Notes on Chap. 3. Sect. 8.* and *Chap. 4. Sect. 6.*) found, that the *Gregorian Epact* for A. D. 1712 is 22, and that the *Gregorian Sunday-Letters* are CB, *viz.* C to the intercalated Day in *February* and after that B; which last Letter B is therefore the *Sunday Letter*, whereby you are to be guided in finding *Easter-Day*. Now by the foregoing Table you learn, that when the *Gregorian Epact* is 22, the *Easter Full Moon* according to the *Gregorian Account* will fall on *March 22d*, N. S. (*i. e.* *March 11th*, O. S.) to which answers the Letter D, as may be seen in the foregoing Calendar. Wherefore reckoning in an Alphabetical Order from D to B, which last is the *Gregorian Sunday Letter*, you'll find, that according to the *Gregorian Computation*, *Easter Sunday* will be *March 27th*, N. S. which answers to our *March 16th*; and consequently, the *Gregorian Easter-Day* will fall A. D. 1718, five Weeks before our *Easter-Day*, this falling on *April 20th*, as has been afore shewn.

It only remains to observe in short, that it having been shewn, how to find both the *Julian* and *Gregorian Easter-Day*, thereby may be known the Time of all the *Moveable Festivals* in any given Year; forasmuch as they all depend on *Easter-Day*. And consequently hereby, and by what has been said of finding the Days whereon fall the New and Full-Moons, may be drawn up an *Almanack* sufficient for common Use. And thus I have laid together so much of Chronology, as seems requisite to be known by Young Gentlemen, at least at their first Institution in the said Art or Science.

FINIS.

THE
Young Gentleman's
DIALLING,

Containing such

ELEMENTS of the said Art,
as are most useful and easy to
be known.

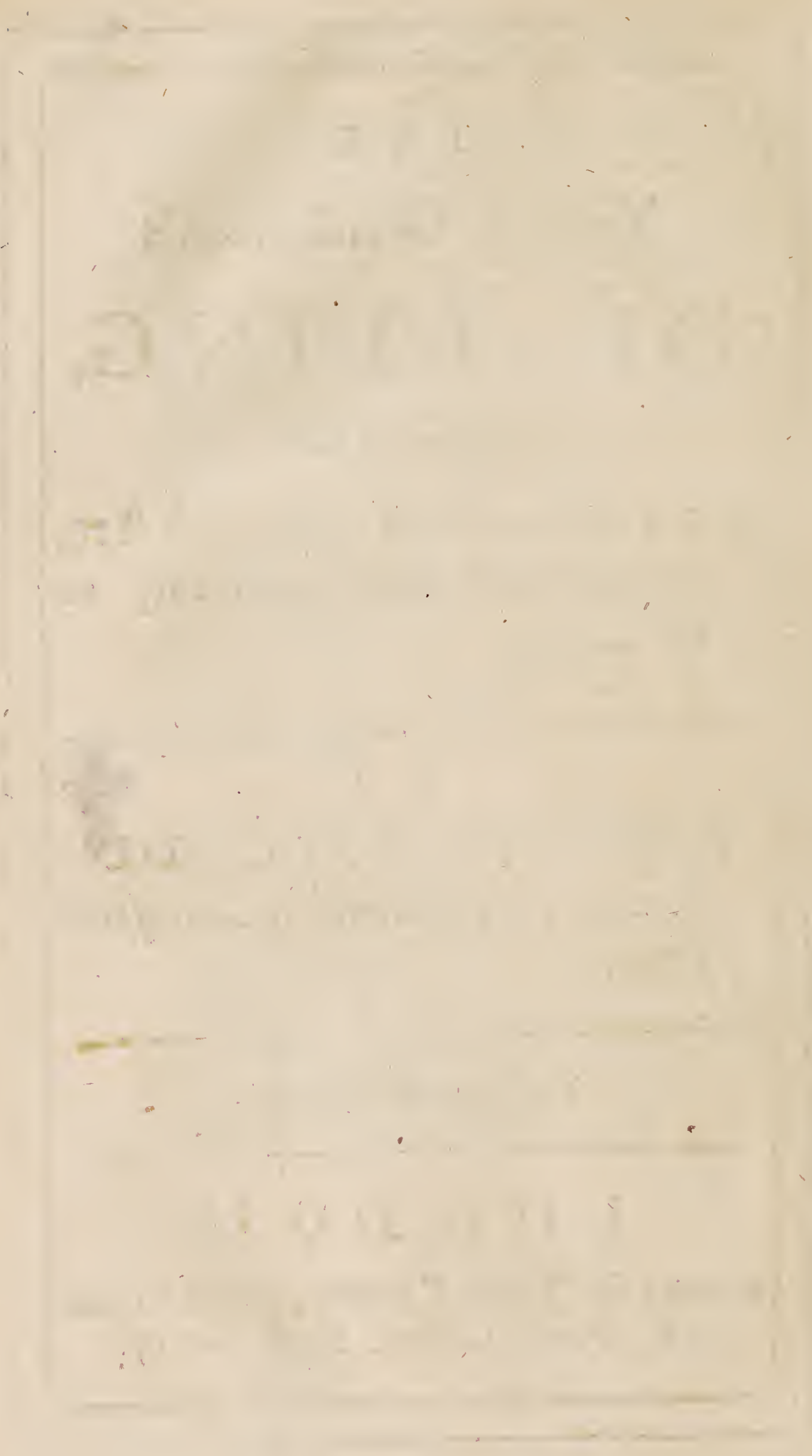
BY

EDWARD WELLS, D.D.
Rector of *Cotesbach* in *Leicestershire*.

The Second Edition.

L O N D O N,

Printed for *James Knapton*, at the *Crown*
in *St. Paul's Church-Yard*. 1717.



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THE
PREFACE.

A*S the Dependance of
the Art of Dial-
ling upon Astrono-
my, was the Reason of my
Drawing up and Publishing
this Treatise, at the same
Time with my Astronomical
Treatise ; so my Design in
drawing up this Treatise, and
the Reason of my giving it
the Title of The Young
R 3 Gen-*

The Preface.

Gentleman's Dialling, may be learnt from the Preface to my Treatise of Astronomy, entituled in like manner The Young Gentleman's Astronomy. I need only observe further, that I have not contented my self with laying down in this Treatise the bare Practical Part of Dialling, but have added thereunto the Reasons or Grounds of such Practice, as most proper to be known by Young Gentlemen; and withal have observed, in the Annotations to this Treatise, how the Grounds of Dialling may be most naturally represented
even

The Preface.

*even to the Eye, by the
Help of a Machine or In-
strument, which from its
Use may be called a Dialling
Sphere*

R 4 THE

THE
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or West, North or South)
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A Ca-

The Contents.

A CATALOGUE of the several
Draughts of Dials, and of
other Cuts, belonging to this
Treatise. 54

IN AND THE

T H E
Young Gentleman's
D I A L L I N G, &c.

C H A P. I

Of Dialling in general.

BY (*) *Dialling* is understood
the Art of Shewing the Time ^{I.} *Dialling,*
of the Day, by the Sun's ^{what.}
Shade falling on some Surface,
whether Plain or not Plain.

(*) The Word *Dial* is derived from *Dies*, because thereupon the Time of the *Day* is shewn. And from the peculiar Manner of shewing the Time of the Day upon a Dial, viz. by the *Shadow* of the Sun, this Art is frequently termed *Ars Scioterica*, i. e. the *Shadow-Art*, from the Greek Word *σῆα*, denoting a *Shadow* or *Shade*.

Plain

Of Dialling.

2. Plain Surfaces are most useful, and therefore most used: for which Reasons we will here speak only of *Plain-Dialling*, i. e. of drawing Dials on Plain Surfaces, simply called *Planes*.

3. Every Dial-plane (i. e. plain Surface on which a Dial is drawn) represents the Plane of some (†) Circle in the Heavens. If the Dial-plane represents

The various Names of Dials, and the Reason of the said Names.

(†) This, and the whole Foundation of Dialling, is most naturally, and so most clearly illustrated by the Help of an Instrument or Machine, which may be properly enough called from its Use a *Dialling Sphere*. It need consist but of an *Horizon*, and two (Wooden or Brass) Circles fastened together, crossing each other at Right Angles, and so as to bisect one the other. Either of these Circles may be taken to represent the *Meridian*, and the other the *Equator*. The former is to be divided into four 90 Degrees, and the latter into 360, as in other Spheres or Globes. And in like manner, as in other Spheres, the *Meridian* of this Dialling Sphere must be let into the *Horizon* at the North and South Points of it. There must be a plain Piece of Board to move up and down within the fore-mentioned Circles, so as to represent the Position of any Dial-plane. And through the Center or middle Point of the plain piece of Board, there must be made an Hole through which, when there is occasion, a String is to be put; which String being also put through the two Points of the *Meridian*, which are 90 Degrees each from the *Equator*, will represent the Axis of the World. The Dialling Sphere being thus prepared, the Manner how the Sun by the Shade of the Style of the Dial, comes to shew the Time of the Day on any Dial-plane, may be ocularly demonstrated,

Of Dialling.

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represents the Plane of the *Horizon*, the Dial is called an *Horizontal* Dial. If the Dial-plane represents the Plane of the Prime Vertical, then the Dial is called an *Erect Direct North* or *South* Dial, respectively as the Dial is drawn on the north or south Side of the said Dial-plane. If the Dial-plane represents the Plane of the *Meridian*, the Dial is called an *Erect Direct East* or *West* Dial, respectively as the Dial is drawn on the east or west side of such a Dial-plane. If the Dial-plane represents the Plane of any other Vertical Circle, besides the Prime Vertical and *Meridian*, then the Dial is called a *Declining* Dial; forasmuch as it does not directly face any one of the four Cardinal

strated, by moving the *Meridian* of the Dialling Sphere, that the String representing the Axis, may have such a Position as duly answers to the Latitude of the Dial; and by placing the plain Piece of Board in such a Position as to answer (the Plane of that Circle in the Heavens, which is represented by the Dial-plane; or in short, to answer) the Position of the Dial-plane. Then a Candle duly moved round the String in Imitation of the Sun's Motion, will shew by the Shade of the String, how the Shade of the Dial-Style by the Motion of the Sun, shews the Time of the Day on the Dial plane.

Points

Of Dialling.

Points of the Heavens, but declines more or less from them. Lastly, if the Dial-plane represents the Plane of any greater Circle in the Heavens, besides some Vertical Circle or the *Horizon*, then the Dial is called (not an Erect, but) an (||) *Inclining* or *Reclining* Dial, respectively as it is drawn, either on that Side of the Dial-plane, which inclines (or leans forward) towards the *Horizon*; or on the other Side, which reclines (or leans backward) from the *Zenith*. And amongst these are the (*) *Equi-*

(||) These are subdivided into *Direct* Incliners or Recliners, and *Declining* Incliners or Recliners.

(*) The *Equinoctial* Dial is Erect in respect of those who live exactly under the *Celestial Equator*; and likewise the *Polar* Dial is Erect to such as live (if any there be) exactly under either of the two Poles of the World. For in respect of the former Inhabitants, the Plane of the *Equinoctial*, and of the Prime Vertical are one and the same; and in respect of the latter Inhabitants, the Plane of the Prime Vertical, and the Plane of the Circle represented by the Plane of a *Polar* Dial is one and the same. Again, the *Equinoctial* Plane is the same with the *Horizontal* Plane in respect to those that are under the Poles; and the *Polar* Plane is the same with the *Horizontal* Plane, in respect of those that live under the *Equator*. And the like Change is to be conceived in respect of other Dial-planes, as they regard several Places; every Dial plane being an *Horizontal* Plane at some Place, and on the other Side every *Horizontal* Plane being a Prime Vertical, and *Meridian* (&c.) Plane at some other Places.

noctial

Of Dialling.

noctial and *Polar* Dials. The *Equinoctial* Dial is so called, as being drawn on a Plane, that represents the Plane of the *Equinoctial*. The *Polar* Dial is so called, as being drawn on a Plane, that represents the Plane of that Circle, which passes through the Poles of the World, and also (the Intersection of the *Equator*, and the *Horizon* at the east and west Points, *i. e.* in short) the Poles of the *Meridian*.

Among the several Sorts of Dials 4.
afore-mentioned, the *Equinoctial* Dial ^{Of the Equinoctial Dial.} is the most easy to be drawn; this being done only by drawing a Circle, and dividing it into twenty four equal Parts, (to which right Lines drawn from the Center of the Circle, will represent the several Hour-Lines,) and erecting perpendicularly a Pin in the Center of the Circle for the Style. But because (†) the *Equinoctial* Dial, when thus drawn on one Surface of the Plane, will serve only for one

(†) The like is to be understood also as to the *Polar* Dial; on which Account it is of lesser Use, and therefore the Manner of describing it is omitted in this Treatise.

Of Dialling.

Half of the Year, namely, whilst the Sun is on one Side of the *Equinoctial*; and therefore to make it serve for the whole Year, it must be doubly drawn, *viz.* on the lower as well as upper Side of the Plane; on Account of this and other Inconveniencies, the *Equinoctial* Dial is seldom used. And therefore it had not been taken Notice of here, but that the Knowledge thereof is requisite for the Understanding the Reason of that Method, which (as being the most Natural, and withal easy Method) is principally made Use of in this Treatise, for drawing the other Dials here spoken of. For, as the Reason why the Circle in an *Equinoctial* Dial is divided into twenty-four equal Parts, answering to the twenty-four Hours in a *Nuchthemeron*, is because 15 Degrees, which is a 24th Part of the *Equinoctial* Circle in the Heavens, answer to one Hour's Motion of the Sun; so, because (at the same Time that the Sun is conceived, by the Shade of the Axis of the World, to shew any Hour on the *Equinoctial* Plane, it does also by the same Shade shew, at the Intersection of any other Plane

Of Dialling.

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Plane with the *Equinoctial* Plane, the Point of the said other Plane belonging to the same Hour; or thus, because) the Hour-points of any other Plane are those Points of the said Plane, which fall in with or touch the Hour-Points of the *Equinoctial* Plane, at the common Intersection of the said two Planes; therefore by the Help of the *Equinoctial* Dial may be drawn other Dials, namely, the *Equinoctial* Dial being duly applied to the Plane given, the Hour Points of the *Equinoctial* Dial will fall on the correspondent Hour-points of (the Dial to be drawn on the) Plane given.

And this will be distinctly exemplified as to the several Sorts of Dials above-mentioned, (excepting Inclining and Reclining Dials, as being of lesser Use) after that it has been here observed further in general, that the whole Business of Dialling may be reduced to three general Heads or Operations. Whereof the first consists in finding the Place of the *Substyle*, or where the *Style* is to be placed: the second in drawing the *Hour Lines*: the third and last; either, if the Dial-plane be Moveable, in duly
S Placing

5.
The Business of reducible Dialling to three Heads or Operations.

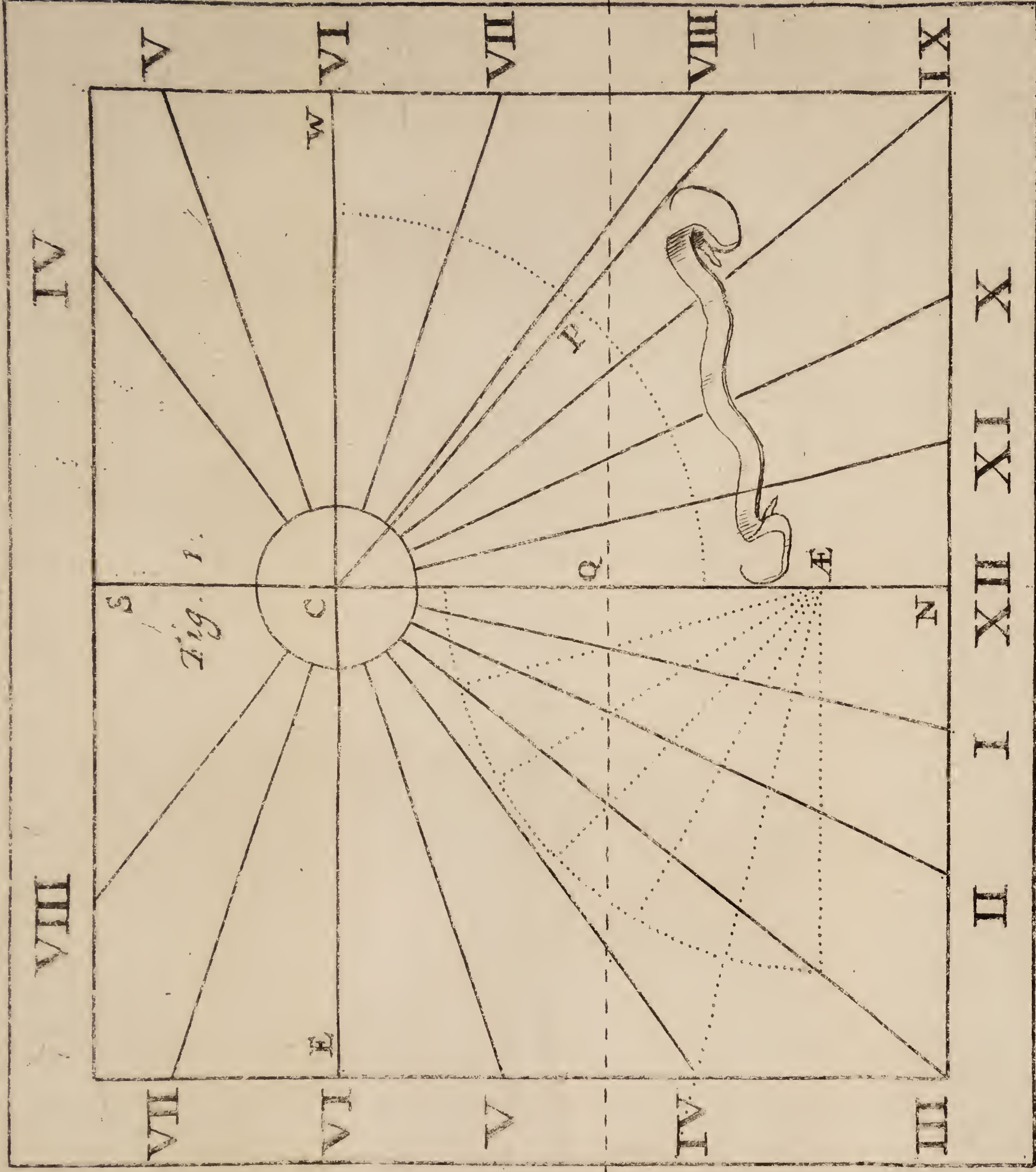
Placing and *Fixing* the same, after that the Dial is drawn thereon; or else, if the Plane whereon the Dial is to be drawn, be unmoveable and already fixed, in Finding the *Position* or Situation of the said Plane, *viz.* whether it be a Direct or Declining Plane; and if the latter, how far it declines.



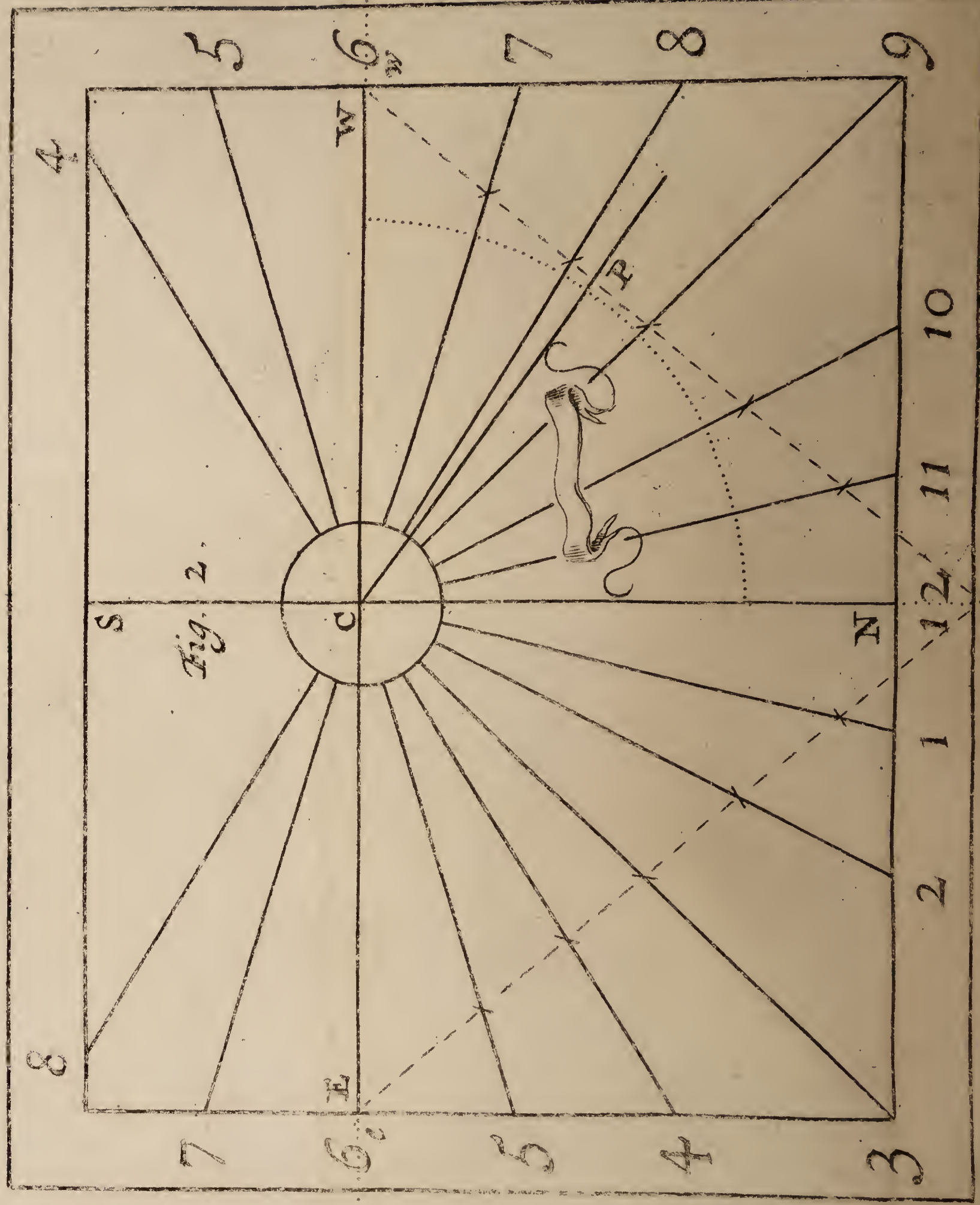
An HORIZONTAL Dial drawn by y^e help of y^e EQUINOCTIAL Dial.

Dial Plate 1.

*Place this
facing p. 9.*



*Place this
facing p. 8.*



An HORIZONTAL Dial drawn by y^e help of Dialling Scale

C H A P. II.

Of an Horizontal Dial.

I Begin with the *Horizontal* Dial, as being the most Useful; forasmuch as it singly answers the whole (*) End of Dialling, by shewing the Time of the Day from Sun-rising to Sun-setting throughout the whole Year, within that *Horizon* for which it is made: whereas no other Dial does this. And having made this Observation as to the Usefulness of the *Horizontal* Dial, we proceed now to the Declination thereof.

I.
The Horizontal Dial, why first spoken of.

Whereas the four Cardinal Points of the Heavens are distant one from the other 90 Degrees; and whereas the *Meridian* runs from North to South, and the prime Vertical runs a-cross the *Meridian* from East to

2.
To draw the Meridian and Prime Vertical Lines of an Horizontal Dial.

(*) The whole proper End of Dialling is, to shew the Time of the Day by the Sun's Shade. As for shewing the Place of the Sun in the Ecliptick (and the like) by the Shade on a Dial plane, this does not properly belong to Dialling.

Of an Horizontal Dial.

West; hence it follows, that, two right Lines being drawn crossing one the other at right Angles (whose Measure is each 90 Degrees) and either of these two right Lines being taken to represent the *Meridian*, the other will represent the Prime Vertical. That taken to represent the *Meridian*, may be fitly denoted by N S, as running in this Dial from North to South; the other by E W, as running from East to West. See Fig. 1.

3.
The Center of an Horizontal Dial, which.

The Point, where the Lines N S and E W cross one another, denotes (†) that Point in the Plane of the *Horizon*, (as also of the *Meridian* and Prime Vertical) through which the Axis of the World passes. And because the said Point is the (||) Center (of all the said Planes, parti-

(†) This may be evidently shewn by the Help of a Dialling Sphere.

(||) The Axis of the World passing through the Center of the World, which is also the Center of all great Circles in the Heavens, and consequently of the *Horizon*, *Meridian*, and Prime Vertical; hence it follows, that That Point in the Planes of the said Circles, through which the Axis of the World passes, must be the Center of the said Planes.

cularly)

Of an Horizontal Dial.

I I

cularly) of the *Horizontal* Plane, whereon the Dial is to be drawn, and consequently the Center of the Dial it self, hence it may be fitly marked or denoted by C, as *Fig. 1.*

The Axis of the World being the 4.
(*) common Interfection of the Planes <sup>Of the Sub-
style and
Style.</sup> of all *Meridians*, and therefore running from Pole to Pole along the Plane of every *Meridian*; hence the Line N S representing the Plane of the *Meridian* of that Place, for which the Dial is made, must be the *Substyle*, or the Line whereon the (†) *Style*, which represents the Axis of the World is to be (||) erected.

(*) This may also be evidently shewn by the Help of the Dialling Sphere.

(†) It is so called, because it needs be, and often actually is, no more than a long straight Iron Pin, like an Engraving or old Sort of writing Pin, called a *Style*. It is called also by a *Latin* Word, the *Index*, because it tells or *shews* what is the Time of the Day. And it is called likewise by a *Greek* Word the *Gnomon*, (from γνῶω to know) because thereby is known the Time of the Day.

(||) By being erected is understood here, and all along this Tract of Dialling, being placed *perpendicularly* upon the *Substyle*, so as not to lean any Thing more towards the Hour-lines on one Side of the *Substyle*, than towards the Hour-lines on the other Side of the *Substyle*.

Of an Horizontal Dial.

And because the Style does represent the Axis of the World, therefore it must be so erected upon the Substyle, (which is the common Intersection of the *Horizontal* and *Meridian* Planes) as therewith to make an Angle equal to the Elevation of the respective (North or South) Pole above the *Horizon* of the Place, or (which comes to the same) to the (*) Latitude of the Place. Wherefore taking C for the Center, draw (†) an Arch of a Circle from N S (on either Side) to E W. On the said Arch (||) set off from N S towards E W, (*viz.* at P, *Fig.* I.)

(*) How the Elevation of the Pole and Latitude of the Place come to be always Equal, may be evidently shewn on the Globe.

(†) This Arch may be drawn, at what Extent of the Compasses or Distance from the Center you please; but it is convenient to have regard to the Largeness of the designed Dial. And also it is convenient to make Use of a *Line of Chords*, in this, and all such Operations, in Order to the setting off on the Arch drawn any Number of Degrees, with much more Ease and Readiness than can be done otherwise. The Reader is here supposed to be already instructed in the Use of the *Line of Chords*.

(||) That is, the Style, if it be only a long straight Piece of Iron, must be so placed on the Substyle of the Dial, as to have the same Inclination thereto, as C P has

Of an Horizontal Dial.

13

1.) so many Degrees as answer to the Elevation of the Pole; for Instance (*Fig. 1.*) $51\frac{1}{2}$ the Latitude of *London*, or Elevation of the north Pole there. The Line CP being drawn will shew the Style.

Having found the Substyle NS, 5. and the Style CP, draw a long Line crossing the Substyle in any Point, (which shall seem most convenient,) suppose Q, at right Angles. This Line representing the common Interfection of the *Equinoctial* Plane and Dial Plane, is therefore called the (*) *Contingent* Line, and is denoted (*Fig. 1.*) by the Line TG. That Point in the Substyle, which is so far distant from Q, as the Point Q is found by the Compasses to be distant from the nearest Point of the Style, represents the Center of the *Equator*,

5.
Of the
Contingent Line,
and applying the
Equinoctial Dial to
the Plane
of your
Horizontal
Dial.

has to N S. If you would have the Style a broad Plate of Iron or the like, then it must be made exactly equal to the Triangle NCP. In both Cases, the lower Point of the Style, namely, wherein the Lines CN and P n meet, must be placed exactly on C, as being the Point of the *Horizontal* Plane, through which passes the Axis, represented by the Style

(*) It is so called, because herein the two Planes are conceived to touch one another.

Of an Horizontal Dial.

or that Point from which an *Equinoctial* Dial is to be delineated on the Dial-plane, and therefore it may fitly be marked *Æ*. Taking then *Æ* for the Center, at (†) any Distance, draw toward the Contingent a (||) Semicircle representing half the *Equinoctial*, so as that one Half of the Semicircle (*i. e.* fourth Part of the *Equinoctial*) may be on each Side of the Substyle. Then divide the said Semicircle into twelve equal Parts, (*viz.* six on each Side of the Substyle,) each containing an Arch of 15 Degrees, (*) Lines drawn from *Æ* the

(†) However it is convenient to be guided herein by the Length of the Line of Chords made use of, and by the Size of the intended Dial.

(||) This may be otherwise done by only drawing one Half of this Semicircle on one Side of the Substyle, and dividing it into six equal Parts; and thence transferring the said six Divisions to that Part of the Contingent, which is on the other Side of the Substyle. And this is the best Way for practice, being shorter, and not cumbring the Work with Multitude of Lines. And 'tis adviseable to draw the said Quadrant, or fourth Part of the *Equinoctial* Circle or Dial on that Side of the Substyle, where the Style is not drawn: because then the *Equinoctial* Dial and the Style will stand both clear one from the other; as in the Figures hereunto belonging.

(*) These, and all other Lines or Circles or Arches of Circles are to be *obscure* ones, *i. e.* such as may be rubbed out again, excepting only the proper Hour-lines

Of an Horizontal Dial.

15

Æ the Center of the *Equinoctial* to each Division of the Semicircle will be the Hour Lines of the *Equinoctial* Plane or Dial; among which Hour Lines, the Substyle and *Meridian* NS of the *Horizontal* Dial will also be the *Meridian* of the *Equinoctial* Dial.

Having thus fitted the *Equinoctial* Dial to the *Horizontal* Plane, on which the *Horizontal* Dial is to be drawn, it will be very easy to find the Hour-points of the said *Horizontal* Dial: namely, by continuing the *Equinoctial* Hour-lines to the Contingent, and thereby seeing, on what Points of the *Horizontal* Plane the Hour-lines of the *Equinoctial* Plane will fall. For the said Points of the *Horizontal* Plane are respectively the Points, on which the correspondent Hour-lines of the *Horizontal* Dial will fall, being drawn from (†) C the Center of the *Horizontal* Dial. Among

6.

To draw
the Hour-
lines of an
Horizontal
Dial.

lines in each Dial. These obscure Lines are distinguished in the Draughts hereunto belonging by being made prick'd Lines.

(†) The Hour-lines represent the Shade conceived to be made by the Axis of the World; which Axis being

Of an Horizontal Dial.

mong these Hour-lines, the Line NS being both the *Meridian* and *Substyle* of the *Horizontal* Dial, (and so falling in with the *Meridian* of the *Equinoctial* Dial) will therefore be the twelve a Clock Line of the *Horizontal* (as well as *Equinoctial*) Dial. Which being known, the Numbers 11, 10, 9, 8, and 7. are to be affixed to the Hour-lines on the west Side of the Dial, according to their respective Order from the twelve a Clock Line. And in like manner the Numbers, 1, 2, 3, 4, and 5, are to be set to the respective Hour-lines on the east Side of the Dial. The Line EW, as representing the Prime Vertical, is always the 6 a Clock Line, both Morning

being conceived to pass through C the Center of the Dial, hence all the Hour-lines must be drawn from the said Center. Only it is observable, that it is more Ornamental, not to draw actually the Hour-lines from C (because if they were so drawn, they would be apt to run together, and blot at the point C,) but making a Circle at some small distance from C, actually to draw the Hour-lines only from the said Circle, by the Ruler duly applied to C, as *Fig. 1.* 'Tis also observable, that the Dial-plane may be of any Shape, viz. Round or Triangular, &c. as well as Square or Oblong, though this Shape is most used among us.

and

and Evening. And as for the Hours before six in the Morning, and after six in the Evening, their Lines are drawn by continuing the Lines of those Hours, which are of the same Denomination in the contrary Part of the Day, through the Center C of the Dial. Thus the Hour-lines of 5 and 4 in the Morning are drawn, by continuing the Hour-lines of 5 and 4 in the Afternoon through C. And the Hour-lines of 7 and 8 in the Evening are drawn, by continuing the Hour-lines of 7 and 8 in the Morning thro' C. And thus the Delineation of an *Horizontal* Dial is finished, (as is represented, *Fig. 1.*) according to the Method of Delineating the same by the Help of an *Equinoctial* Dial. For as to the intermediate Spaces between each Hour, (*viz.* Quarter, Half, and three Quarters,) they are had by dividing the Space between each two Hours, first into Half, and each Half again into Quarters.

It

Of an Horizontal Dial.

7.
To draw
an Hori-
zontal Dial
by a Dial-
ling Scale.

It may not be unuseful (not only for Variety, (†) but also Proof sake) to add here the Method of drawing an *Horizontal* Dial, by Dialling Scales and Tables. The former is thus : The Lines NS and EW being drawn, and the Style CP erected, as afore ; the Length of the Line EW is to be determined, so as to bear a due Proportion to the Scale of Hours you are to Use. This is done by placing one Foot of the Compasses at the Beginning of the Scale of *Latitudes*, (contained in the Dialling Scale,) and opening the other Foot, till it reaches to the Number of Degrees in the said Scale of Latitude, which answers to the Latitude of the Place. This Extent is to be set off on the Line E. W. from C towards E, and also toward W ; and where it Ends, it may be respectively marked *e*, *w*, as Fig. 2.

(†) If you have drawn your Dials right, the same Hour-lines, at equal Distance from the Center of your Dial, will be equally distant also one from the other, by which Method soever you draw them. v. g. The Distance between 12 and 1, (or 12 and 2, or 1 and 2, &c.) will be the same, at equal Distance from the Center of your Dial, whether it be drawn by the *Equinoctial* Dial, or by Scales, or by Tables.

Then

Of an Horizontal Dial. 19

Then out of the Dialling Scale take the whole Length of the Scale of *Hours*, with the Compasses ; and setting one Foot of the Compasses in *e*, with the other make an Arch crossing the Line *NS* towards *N* ; and then do the like on *w*. From the Point α of the Line *NS*, where the two Arches (||) cross one another, draw the Lines αe and αw ; which will be of an equal Length with the Scale of Hours in the Dialling Scale : from which Hour-scale the several Hours (and the intermediate Spaces) are to be respectively transferred unto the Lines αe and αw . Lines drawn from *C* to the several Hour-points on the Lines αe and αw , will be the respective Hour-lines. And so the Dial is finished by the Scale : for the Hour-lines before 6 in the Morning, and after 6 in the Evening, are to be had, as afore.

If you would work by Dialling
Tables, having drawn the Lines *NS*

7.
*To draw
an Horizontal
Dial by
Dialling
Tables.*

(||) If the Lines drawn by the Compasses, set upon *e* and *w*, do not cross one the other exactly in some Point of the *Meridian NS*, then some Fault has been made in setting off the said Lines, and the Work must be repeated, till they do thus cross.

and

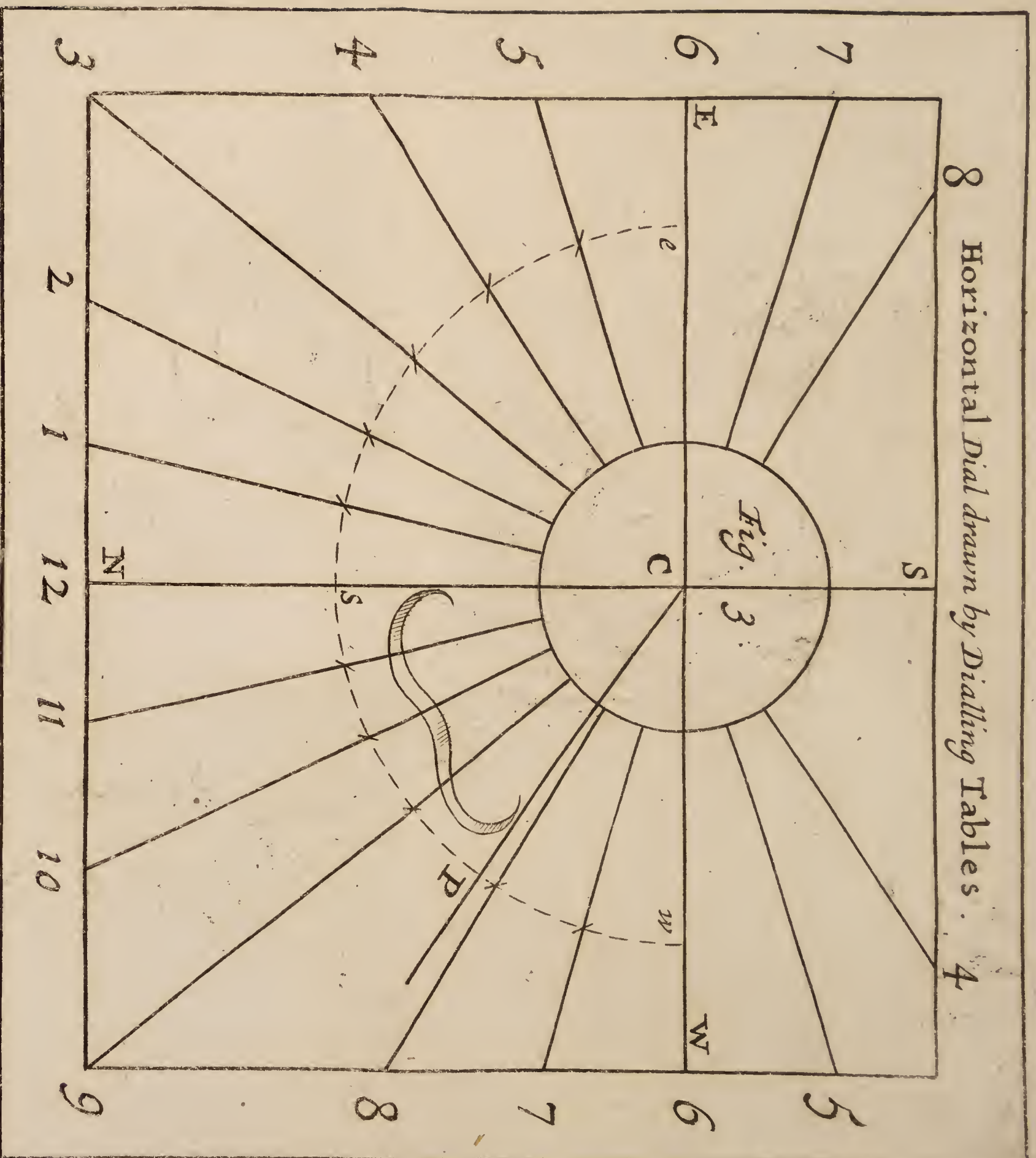
20 . *Of an Horizonral Dial.*

and EW to what Length you please, upon C the Intersection of the said Lines draw a Semicircle *e s w*, as in *Fig. 3.* Then on the said Semicircle set off the Degrees and Minutes answering to each Hour (and each Quarter, Half, or three Quarters of an Hour) in the Table for *Horizontal Dials*. After which draw the Hour-lines from C to the several Hour-points in the said Semicircle. The Substyle and Style are found, as afore.

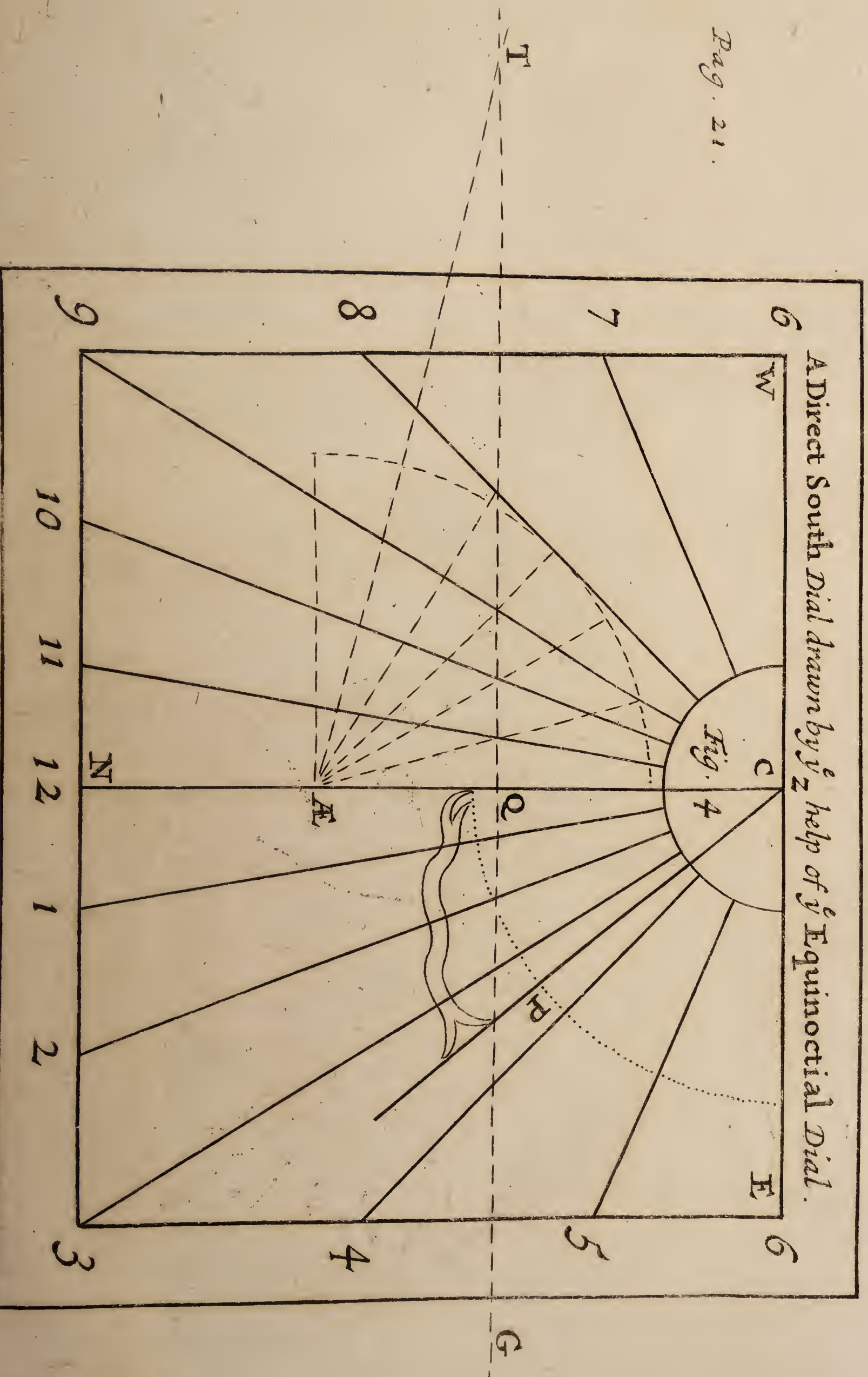
Having shewn, how to draw an *Horizontal Dial* three several Ways, it remains now to shew how to *place aright* the said Dial, when drawn, and this will be best spoken of together with the placing of other Dials, *Chap. 5.*

C H A P.

Place this facing
pag. 20.



Pag. 21.



C H A P. III.

Of an (*) Erect Direct South
and North Dial.

THE Erect Direct South Dial shall be spoken of next, as being next to the *Horizontal* Dial the most useful : forasmuch as it shews the Time of the Day from 6 to 6 throughout the whole Year.

1.

A Direct South Dial the most useful next to an Horizontal Dial.

This Sort of Dial is drawn after the same manner, by the Help of the *Equinoctial*, as the *Horizontal* Dial, excepting the Particulars following ; viz. First, That the *Meridian* or 12 a Clock Line, (which in this, as well as the *Horizontal* Dial, is always the Substyle,) forasmuch as it must be so placed as that one of its Ends must Point to the (†) *Zenith*, the other to the

2.

To draw a Direct South Dial, by the Help of the *Equinoctial* Dial.

(*) Inclining and Reclining Dials being seldom used, hence these Dials are frequently stiled only Direct South and North Dials.

(†) The *Meridian* of any Place or Dial, as it passes through the North and South Poles, so it passes likewise

Of a Direct South Dial.

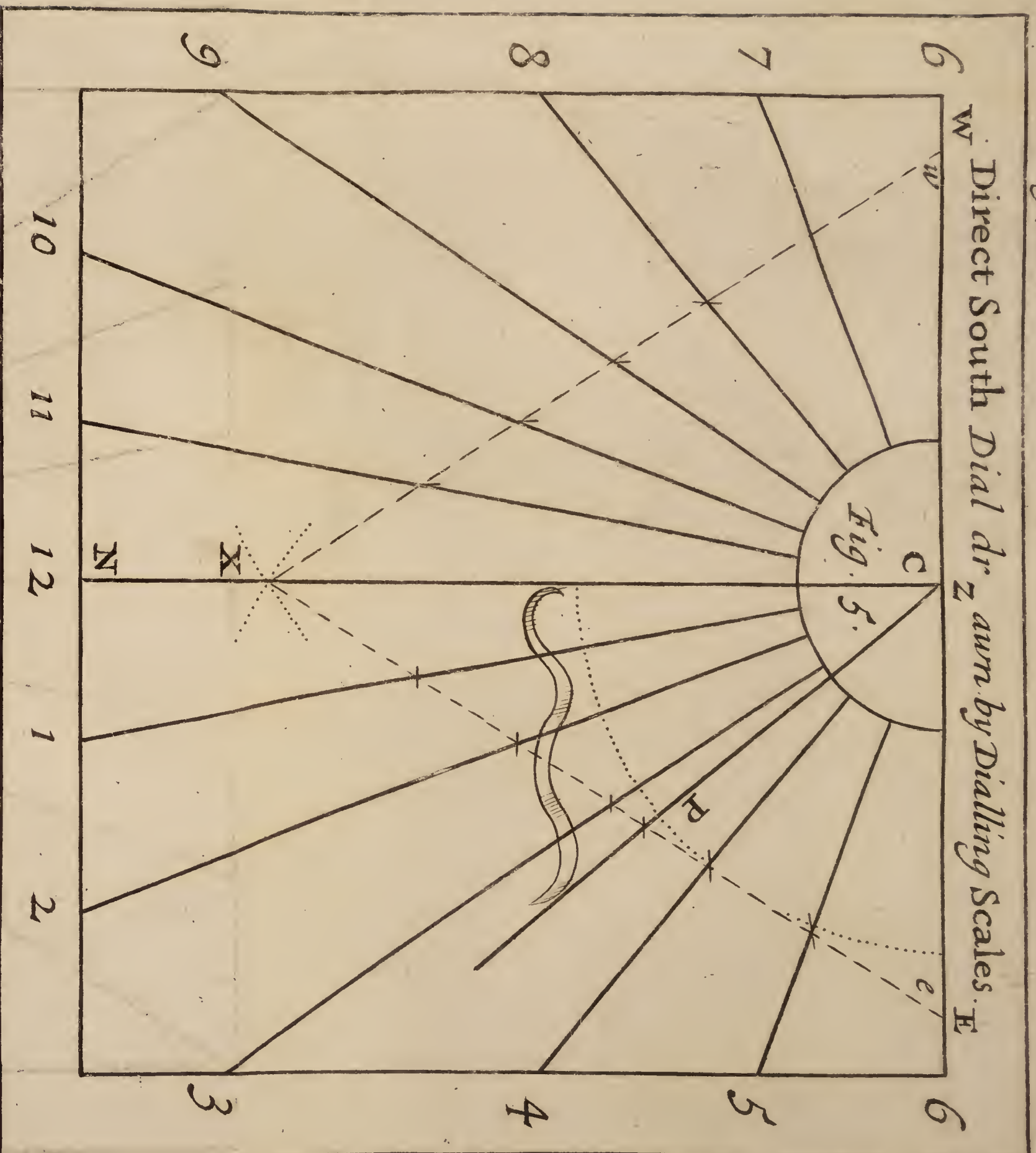
the *Nadir*, may therefore be most properly here denoted by ZN. Secondly, the Style CP must be erected upon the Substyle ZN, so as to make therewith an Angle equal (not to the Elevation of the Pole, as in an *Horizontal* Dial; but) to the Complement of the Pole's Elevation. For such is the Measure of the Angle, which the (||) South Pole, represented by the Style of this Dial, makes with the Plane of the Prime Vertical. Now the Elevation of the Pole above the *Horizon* of *London* being $51\frac{1}{2}$ Degrees, its Complement is $38\frac{1}{2}$ Degrees. Thirdly, On this Dial there need be inscribed no Hour, either before 6 in the Morning, or after 6 in the Evening: for the Plane of this

wise through the *Zenith* and *Nadir* of the said Place. In an *Horizontal* Dial the *Meridian* Line is to be placed with its Ends towards the North and South Points, and therefore is therein fitly denoted by NS. But in a Direct South Dial, the *Meridian* Line is to be placed so, as that its Ends may Point to the *Zenith* and *Nadir*, and therefore is here more fitly denoted by ZN.

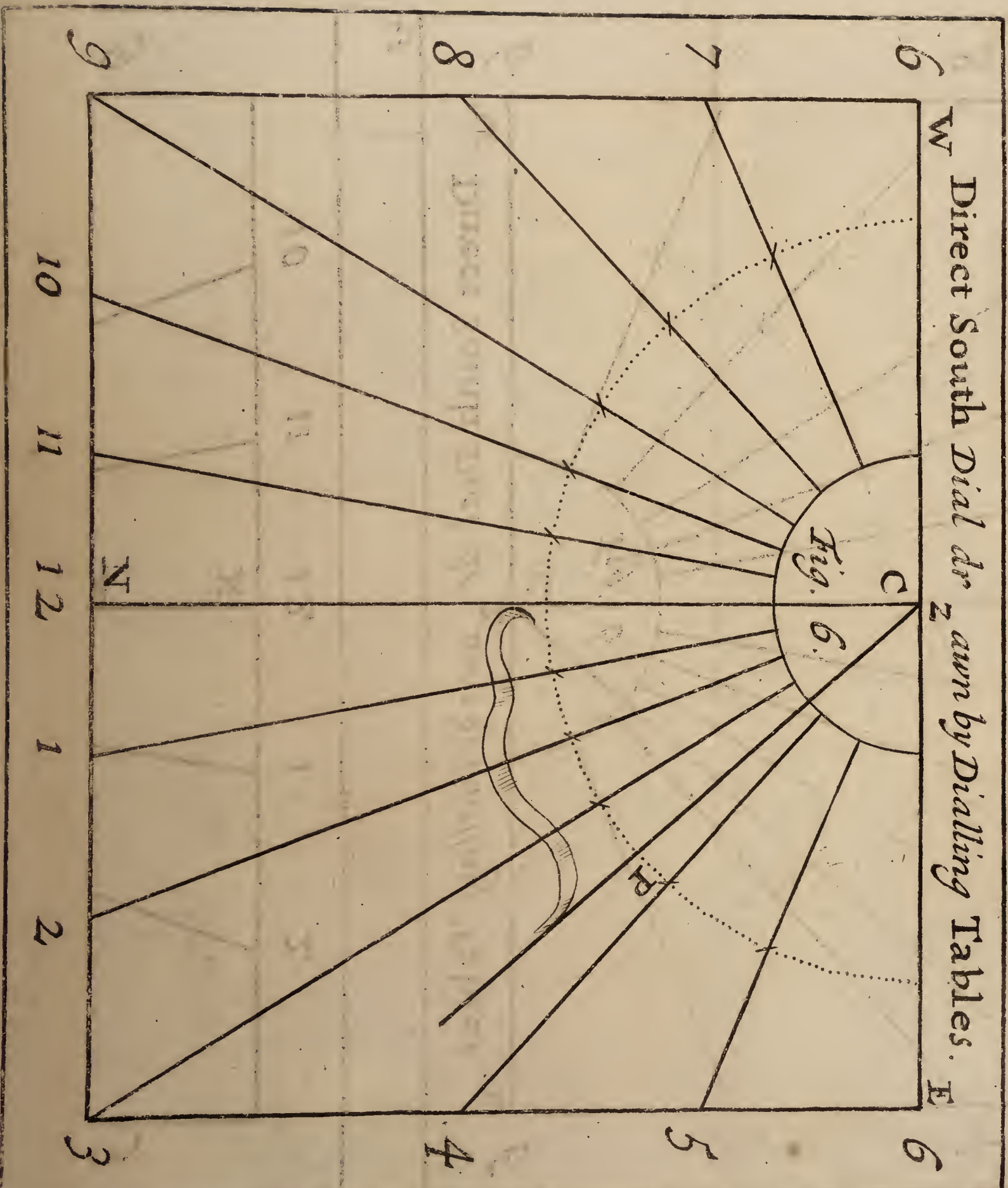
(||) This may be evidently represented to the very Eye by the Dialling Sphere; and consequently the Reason why the End P of this Style must be placed downwards.

Place this facing p. 22.

Dial. Plate 3.



Page 23.



Of a Direct North Dial.

23

Dial representing the south Side of the Plane of the Prime Vertical, the Sun never Shines upon it before 6 in the Morning, or after 6 in the Evening. See *Fig. 4.*

If you work (not by the *Equinoctial* ^{3.} Circle or Dial, but) by a *Dialling* ^{To draw a} Scale, then (besides the fore-mention- ^{Direct} ed Particulars, wherein the drawing ^{South} of this Dial differs from drawing an ^{Dial by a} *Horizontal* ^{Dialling} Dial) it is also to be ^{Scale.} known, that upon the Line E W. from C towards E and W, must be set off the Extent (taken from the Scale of Latitude; not of the Latitude it self, but) of the Complement of the Place's Latitude. See *Fig. 5.*

If you work by Tables, then the ^{4.} Degrees of the Angle, which every ^{To draw} Hour-line makes with ZN the *Meridi-* ^{the same} *an* or Substyle, must be taken from ^{by Dialling} the Table for a Prime Vertical or ^{Tables.} Direct South Dial. See *Fig. 6.*

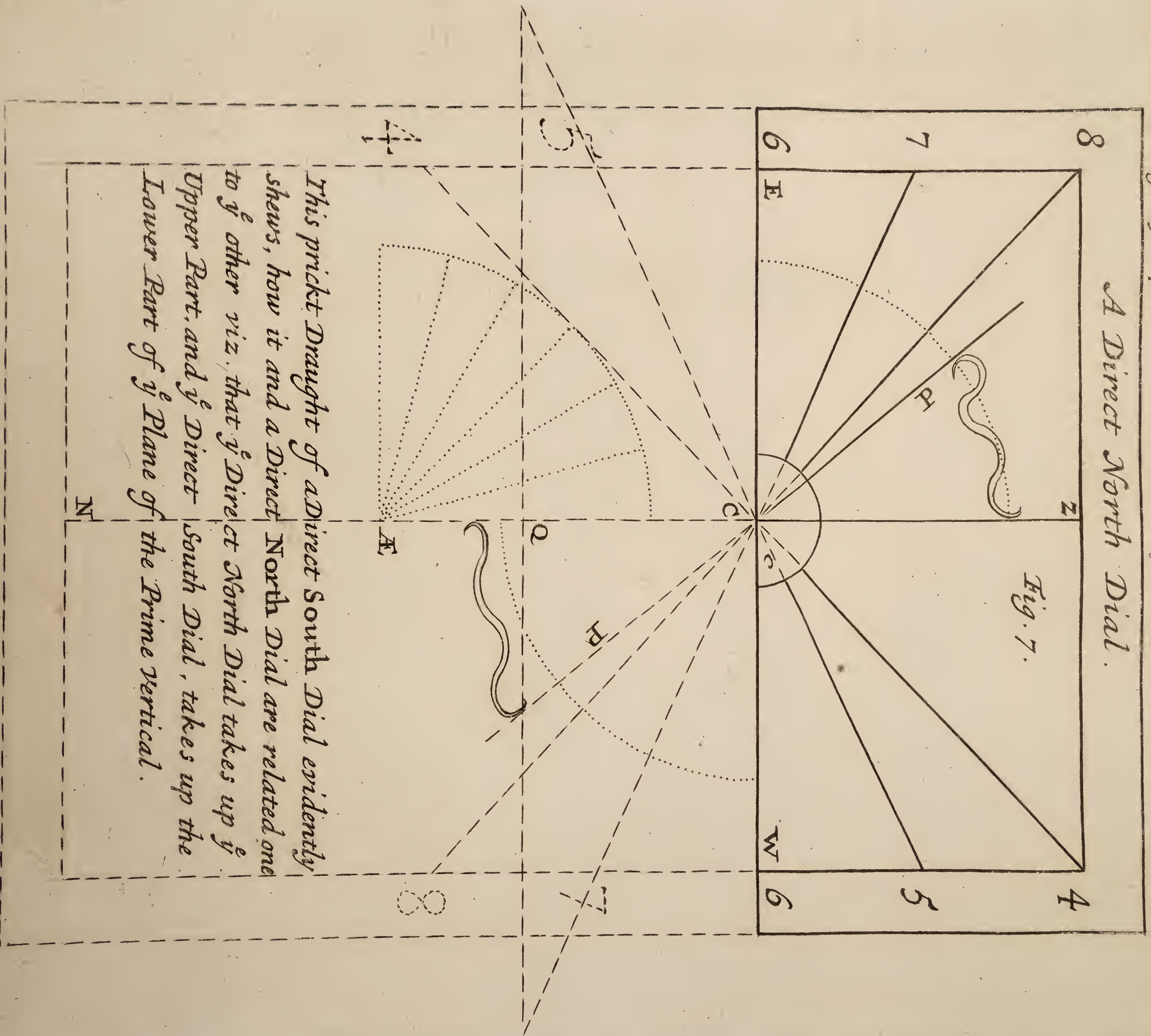
A Direct North Dial differing from ^{5.} a Direct South Dial primarily in this ^{To draw a} alone, that the former represents the ^{Direct} north Side of the Plane of the Prime ^{North} Vertical, and the latter the south ^{Dial.} Side; hence the drawing of a Direct
T North

Of a Direct North-Dial.

North Dial is the same, as of a Direct South Dial; excepting 1st, that the Hours requisite to be inscribed on this Dial in our Country are no more than these, *viz.* 4, 5, 6 in the Morning, and 6, 7, 8 in the Evening. For the Sun with us never rises till after 3 in the Morning, and always sets before 9 in the Evening; and from 6 in the Morning till 6 in the Evening it turns off from the North to the South Side of the Plane of the Prime Vertical. 2^{dly}, Forasmuch as the Style of this Dial represents the north Segment of the Axis, and so its End P represents the north Pole, therefore the End P must be placed looking upwards toward the north Pole. And consequently that End of the Substyle, which answers to the End P of the Style, must Point towards the *Zenith*, and therefore is here properly to be denoted by Z, and the other End of the Substyle by N, as answering to the *Nadir*, contrary to the Position and Notation of them in a Direct South Dial. See *Fig. 7.*

As

A Direct North Dial.



Of a Direct North Dial.

25

As to the Placing of a Direct South or North Dial, it will be more conveniently spoken of Chap. 5.

T 2 CHAP.

C H A P. IV.

Of an (*) Erect Direct East
or West Dial.

1.
To draw a
Direct
East Dial.

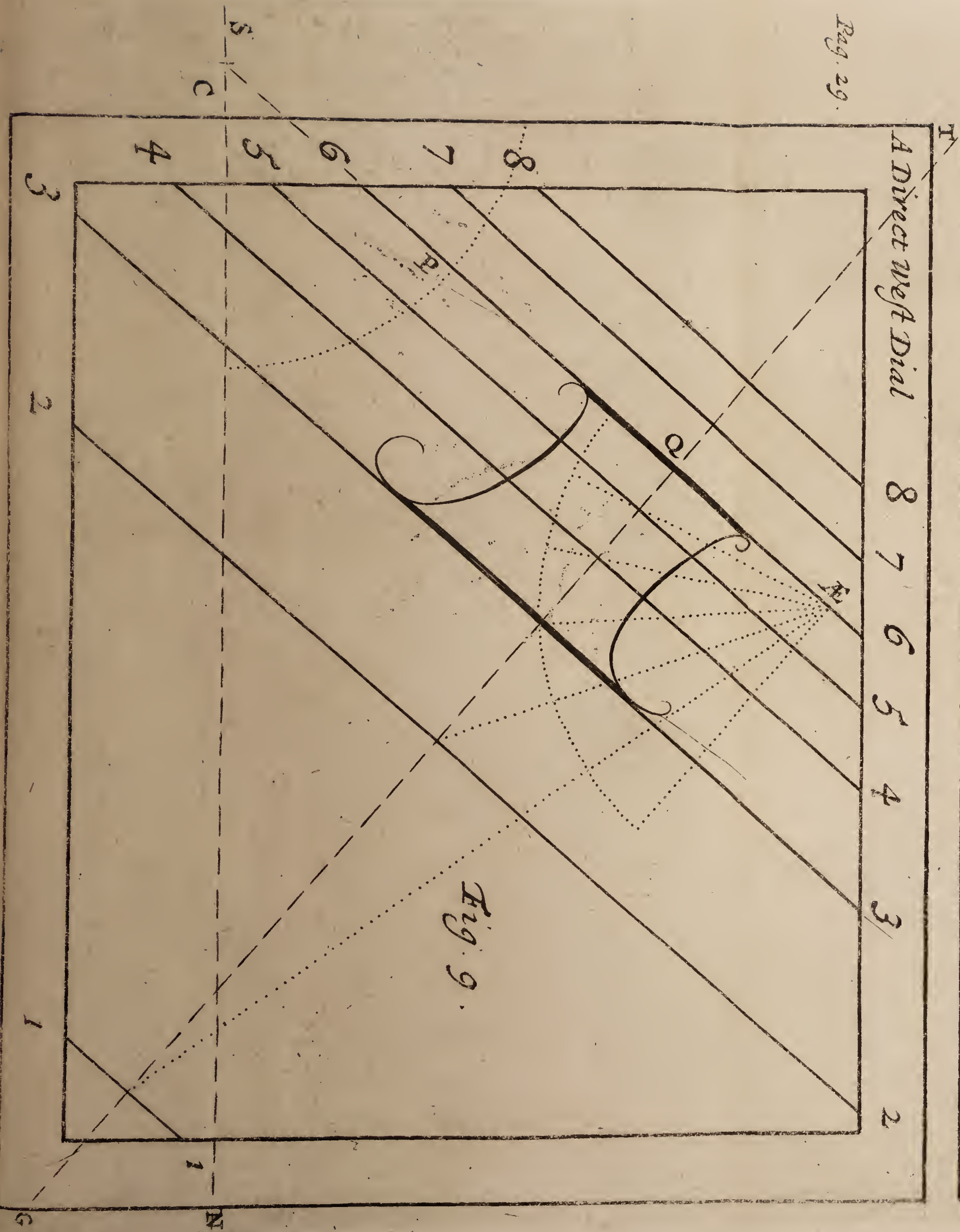
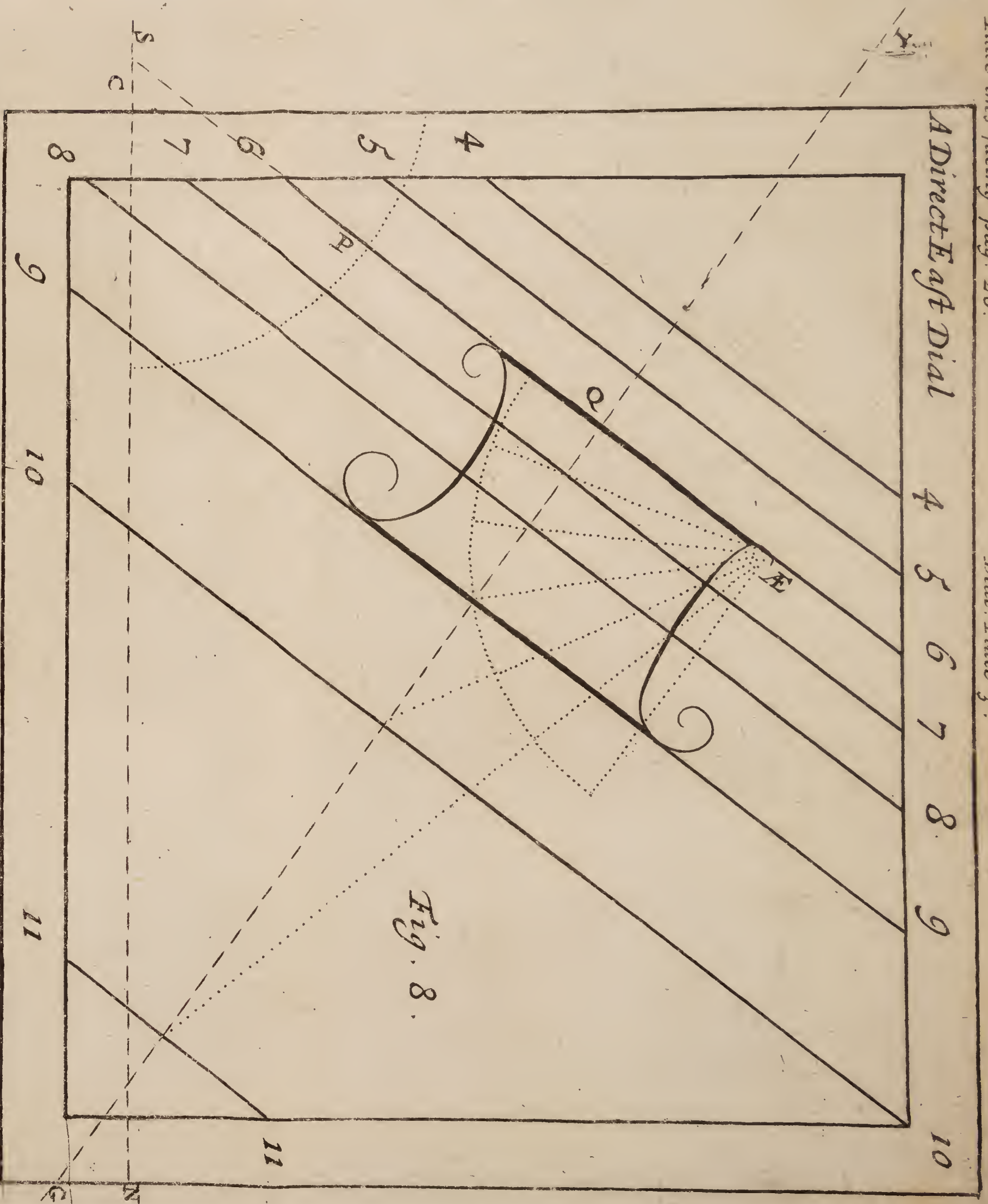
I Begin with a *Direct East Dial*, whose Plane represents the east Side of the Plane of the *Meridian*. Now to draw this Dial, there must be first drawn an *Horizontal Line*, i. e. a Line representing the *Horizon*, or running Parallel to it, and so level. One End of this Line will represent the north Point of the *Horizon*, and may therefore be fitly denoted by N; and the other End by S, as representing the south Point of the *Horizon*. See *Fig. 8*.

2.
To find the
Substyle.

Taking any Point C toward S, the south End of the Line NS for a Center, describe an Arch toward N; and upon that Arch set off the Height P of the Pole, and draw the Line CP for the Substyle.

(*) These also are frequently stiled only *Direct East* or *West Dials*.

Having



Of a Direct East Dial.

27

Having found the Substyle, draw 3.
thereon the Contingent Line T G; To draw the Hour-
and then proceed to draw an (†) E-lines.
quinoctial Dial, taking any point *Æ*
in the Substyle for the Center of the
said *Equinoctial* Dial. That Diameter
of the Semicircle (representing Half
the *Equinoctial* Circle) which runs
Parallel to the Contingent, is here the
Meridian of the *Equator*; from which
you are to begin to divide the Semi-
circle into Hours, or into 6 equal
Parts, each containing 15 Degrees.
Through each of these Divisions of
the *Equinoctial* Semicircle draw Lines
from *Æ* to the Contingent; and a-
gain through each Point of the Con-
tingent, whereon the said Lines fall,
draw other Lines (||) parallel to the
Substyle. These last will be the Hour-
lines; that which falls in with the
Substyle CP being always the 6 a

(†) There is no Mention made of drawing a Direct East or West Dial by *Scales* and *Tables*, because it is in Effect done both Ways, by the Help of the *Equinoctial* Dial.

(||) Because the Axis of the World runs parallel to the Plane of the *Meridian*, (as may be shown by the *Dialling Sphere*,) and so must be conceived to cast its Shade parallel also to its self.

T 3

Clock

Of a Direct East Dial.

Clock Line; those above it the Hour-line of the Hours before 6, and those below it the Hour-lines of the Hours after 6. Where it is to be noted, that as 4 and 5 are the only Hours before 6, which need be inscribed on this Dial; because the Sun never rises to us till after 3; so the Hours to be inscribed on this Dial after 6, are no more than 7, 8, 9, 10, and 11; forasmuch as this Dial-plane representing the Plane of the *Meridian*, the Sun shines not upon its Surface, but upon its south Side or Edge, at 12 a Clock.

4.
To place
the Style.

The Hour-lines being drawn, the Style is to be placed (*) parallel to the Substyle CP, and so far distant from it, as the Center $\text{\AA}$ of the *Equinoctial* was taken distant from the Contingent. And so the Dial is Finished; as *Fig. 8*.

(*) Because the Style represents the Axis of the World, which runs parallel to the Plane of the *Meridian*. Hence Direct East and West Dials have no Centers, through which the Axis passes, and from which consequently are to be drawn all the Hour-lines, as in *Horizontal* and Direct South and North Dials; which are therefore called *Central Dials*.

Of a Direct West Dial.

29

A *Direct West* Dial differing from a Direct East Dial primarily in this alone, that the former represents the west side of the Plane of the *Meridian*, and the latter the east side; hence the drawing of a Direct West Dial, is the same with that of a direct East Dial, excepting only the different denominations of the Hours to be inscribed on this Dial, *viz.* 1 to 8 in the Afternoon; which must be placed respectively from 6, (the Hour-line whereof always falls in with the Substyle,) as the Morning Hours are in a Direct East Dial. See *Fig. 9.*

5.

To draw a
Direct
West Dial.

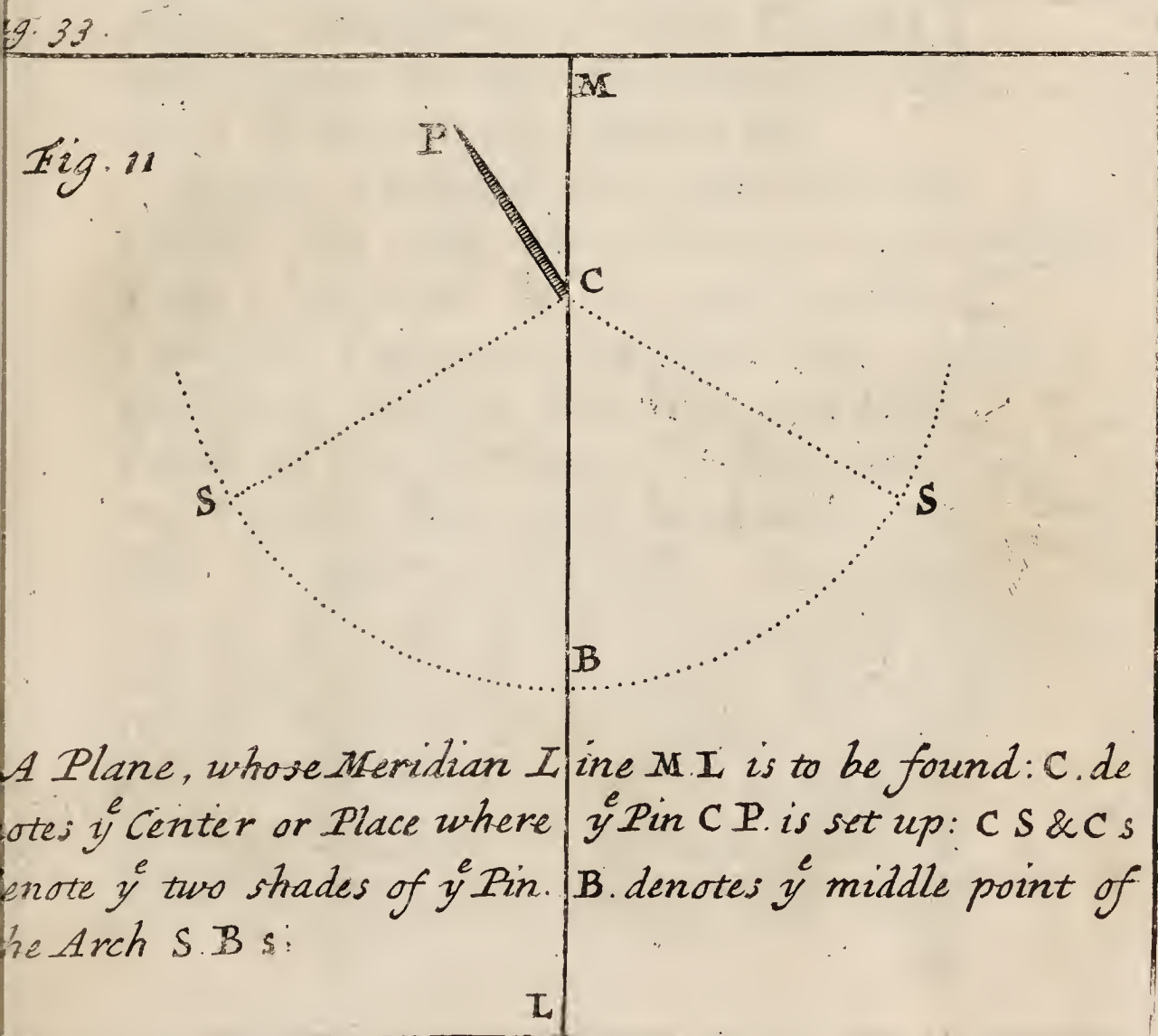
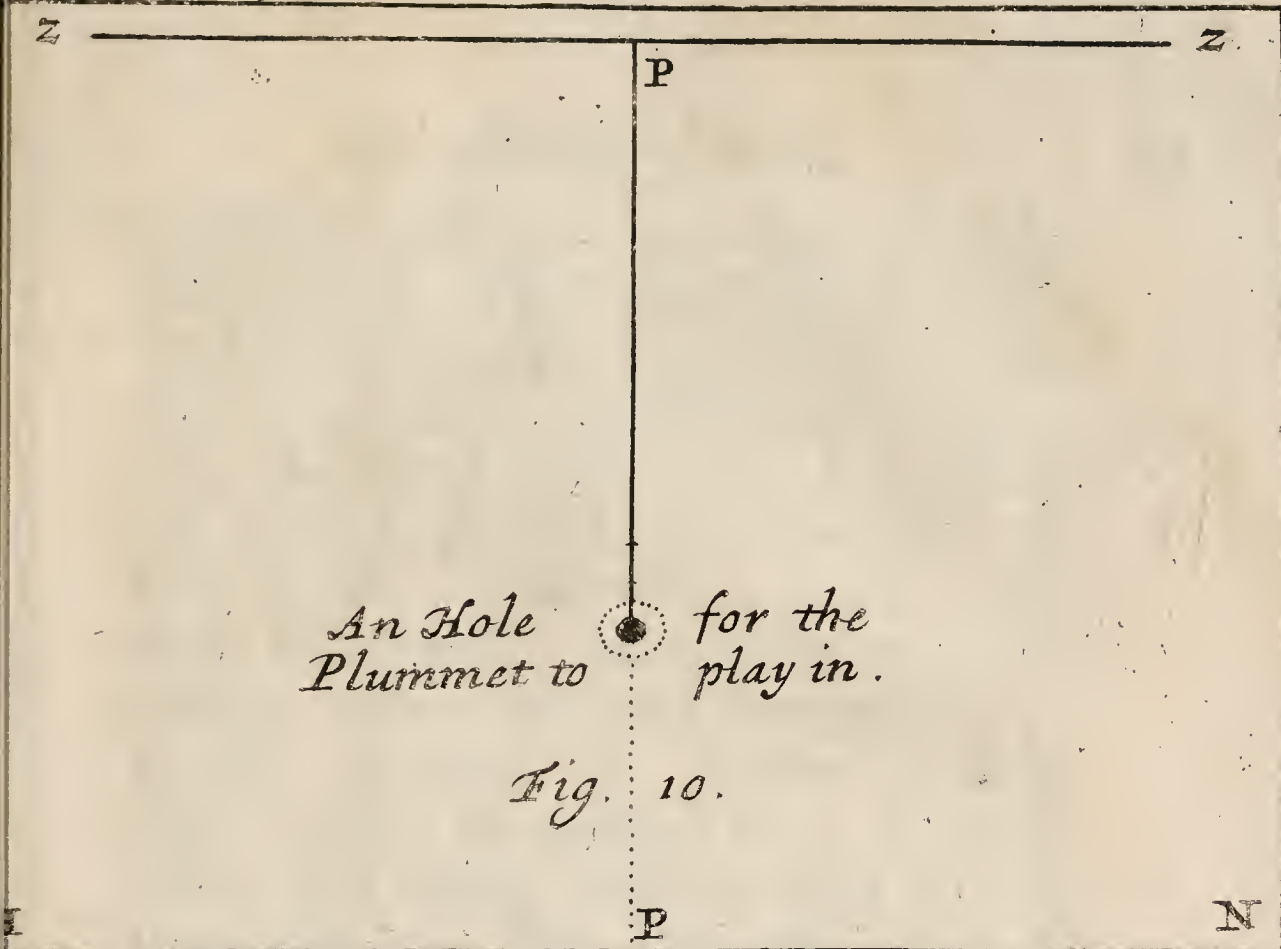
How these Dials, when drawn, are to be placed, so as to have a due Situation in respect of the Heavens, is shewn in the following Chapter.

C H A P. V.

Of duly placing a Direct (East, or West, North, or South,) Dial; and of the Manner of finding, whether a Wall has a Direct or Declining Position or Situation.

I.
A Dial is then duly placed, when its Plane answers to the Plane of the Celestial Circle, which it represents. In order whereto the Dial-plane must be placed parallel its respective Celestial Plane.

EVERY Dial-plane representing the Plane of some Circle in the Heavens, therefore, when any Dial is drawn, that it may go true, it is requisite that its Plane be so placed, as to answer exactly to the Plane of the Celestial Circle, which it represents. Wherefore, if it be an *Horizontal* Dial, its Plane must be placed *Horizontally*, or parallel to the *Horizon*, i. e. exactly level. If it be any *Vertical* Dial, (as a direct North or South, East or West Dial,) it must be placed *Vertically*, i. e. perpendicular to the *Horizon*, or exactly Upright. Now the Instrument represented, Fig. 10, will shew, when any of the fore-mentioned



Of placing Dials.

31

mentioned Dials are thus duly placed. Namely, if, when the Side H N of the said Instrument be applied to the *Horizontal* Dial, the String falls exactly on the perpendicular Line P P, then the Dial is placed *Horizontally*, or truly Level; otherwise it is not, but must be altered, till the String does exactly fall on the said Perpendicular. In like manner, if, when the Side ZN or ZH be applied to a Vertical Dial, the String exactly falls on the Perpendicular P P, then the Dial is placed Vertically, or truly Upright; otherwise it is not, but must be altered till the String does so fall.

Again, an *Horizontal* Dial must be placed not only *Horizontally* in general, but also so, as that the four Cardinal Points of the Dial may respectively answer the like Cardinal Points of the *Horizon*. In like manner Vertical Dials must be placed, not only in general Vertically, but also so, as that the Plane of each Vertical Dial may be parallel or answer to the Plane of that Vertical Circle in the Heavens, which it particularly has respect to. Thus the Plane of a Direct South or North Dial must be

2.
And 2dly,
The Cardinal
Points of
the Dial-
plane must
answer to
the Cardinal
Points
of its re-
spective Ce-
lestial
Plane.

Of Placing Dials.

be so placed, as that it may be parallel to the Plane of the Prime Vertical, which it represents, and that it may respectively answer to the south or north Side of the said Plane of the Prime Vertical. In like manner, the Plane of a Direct East or West Dial must be so placed, as that it may be parallel to, or fall in with the Plane of the *Meridian*, which it represents; and that it may respectively answer to the east or west Side of the said *Meridian* Plane.

3.
To find the
Meridian
Line of
any Plane
or Place.

Now in Order thus to place aright any of the fore-mentioned Dials, it is requisite to find where the *Meridian* crosses the Place, on which you would put the Dial. And this may be done several Ways. The most easy is by the Help of (what is called) the Mariners Needle, supposing it has none, or but little Variation in the Place where you are. For then the *Meridian* runs over, or parallel to the Length of the said Needle. Another Way is by holding up a String, when the Sun is in its *Meridian* Altitude, (which is to be found by the Quadrant,) for then the shade of the String will represent the *Meridian* Line
of

of the Place where you are. Another Way, somewhat longer, but much surer, is this: Any Time in the Morning, when the Sun shines, erect any Pin or straight Piece of Iron or Wood, and mark where the End of its Shade falls. See *Fig. 11.*

Then on the Point, where the Pin was erected, as on a Center, draw a Circle passing through the other Point, where the End of the Pin's Shade fell. After which erecting the Pin again where it was, wait till the End of the Pin's Shade touches the Circle in some other Point. The Arch between the two Points of the Circle, on which the End of the Pin's Shade fell at the two several Times, being bisected or divided exactly in Half, a right Line drawn from the Center of the said Circle (*i. e.* from the Point where the Pin was erected) through the Point of Bisection will be the *Meridian* Line of the Place where you are.

The *Meridian* Line of the Place where you are, being thus found out by one or more of the fore-mentioned Ways, an *Horizontal* Dial is truly placed,

4.
To place a-
right an
Horizontal
Dial.

Of Placing Dials.

placed, (so as that its Cardinal Points shall answer the like Points of the *Horizon*;) by placing the *Meridian* Line (or, which is the same, the 12 a Clock Line) of the said *Horizontal* Dial exactly upon, or parallel to the *Meridian* Line of the Place where you are. For the *Meridian* Line of the Dial being thus placed upon, or parallel to the *Meridian* Line of the Place, the North and South Points of the *Horizontal* Dial, being no other than the North and South Ends of the *Meridian* Line of the Dial, will answer to the North and South Points of the *Horizon* of the Place, these directly answering to the North and South Ends of the *Meridian* Line of the Place. And the North and South Points of the Dial being thus placed so, as to answer to the said Points of the *Horizon*; the East and West Points of the Dial (if rightly drawn) will likewise answer to the East and West Points of the *Horizon*.

5.
To place
aright a
Direct
East or
West Dial.

The Method of placing aright a Direct North or South, East or West (as well as of an *Horizontal*) Dial does likewise depend on the *Meridi-*

Of Placing Dials.

35

an Line of the Place. For having found this by one or more of the Ways above-mentioned, in order to place aright a direct East or West Dial, all that is to be done, is only this, *viz.* directly upon or parallel to the said *Meridian* Line of your Place, you must erect the Dial with the Face of it Eastward, if it be a direct East Dial; or Westward, if it be a direct West Dial.

In order to place aright a direct North or South Dial a little more is to be done. Namely, having found the *Meridian* Line of your Place, you must draw another Line crossing the former perpendicularly, which will be the Prime Vertical Line of the Place. Upon which therefore directly, or parallel to it, must be placed the Dial with the Face of it southward, if it be a direct South Dial; or northward, if it be a direct North Dial.

6.
To place
aright a
Direct
South or
North
Dial.

Hitherto we have considered Dials, as drawn on *Moveable* Planes, or Planes not already Fixed. And on such as are usually drawn *Horizontal* Dials. But Vertical Dials, (whe-

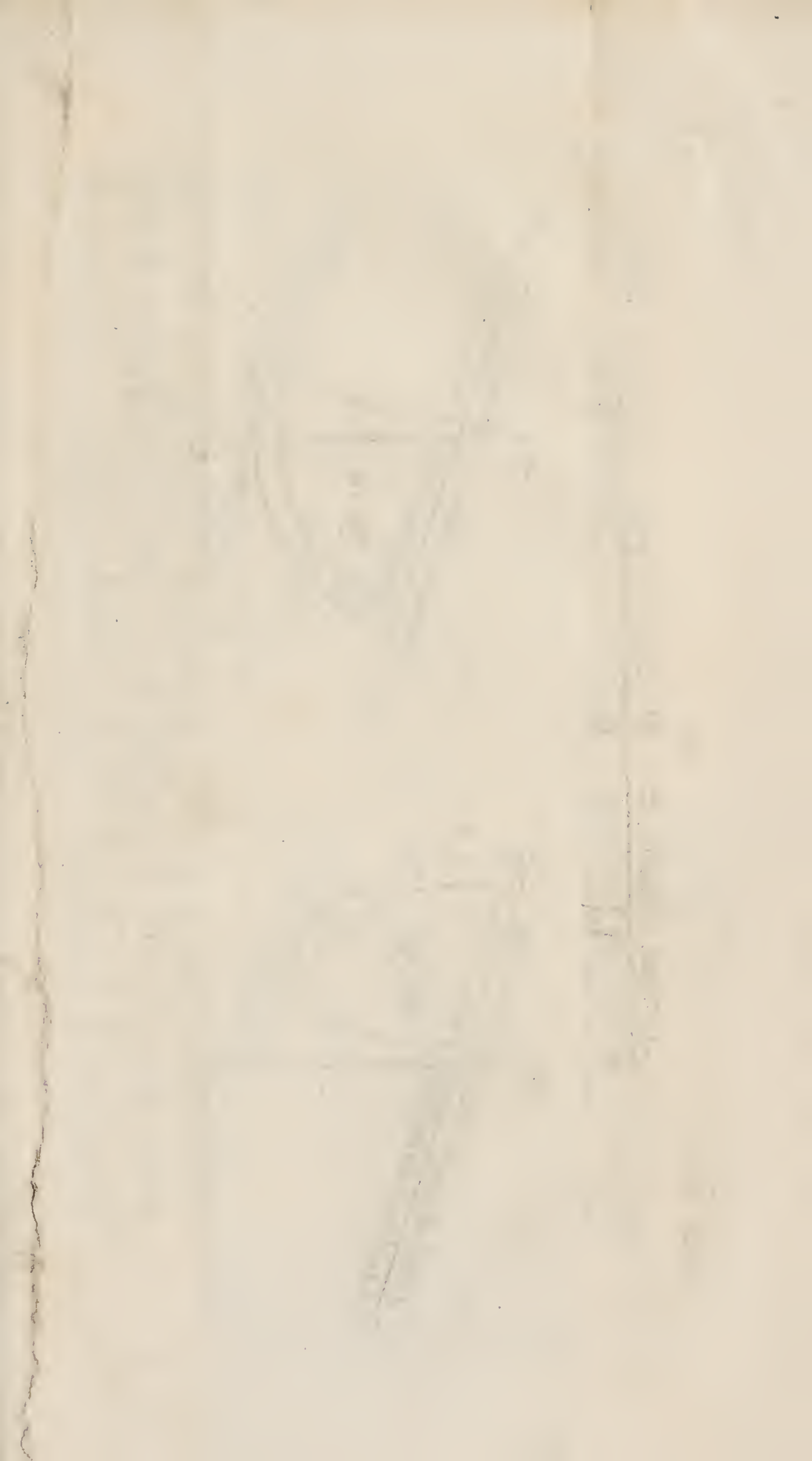
7.
of Unmo-
vable or
Fixed
Dial-
planes.

ther

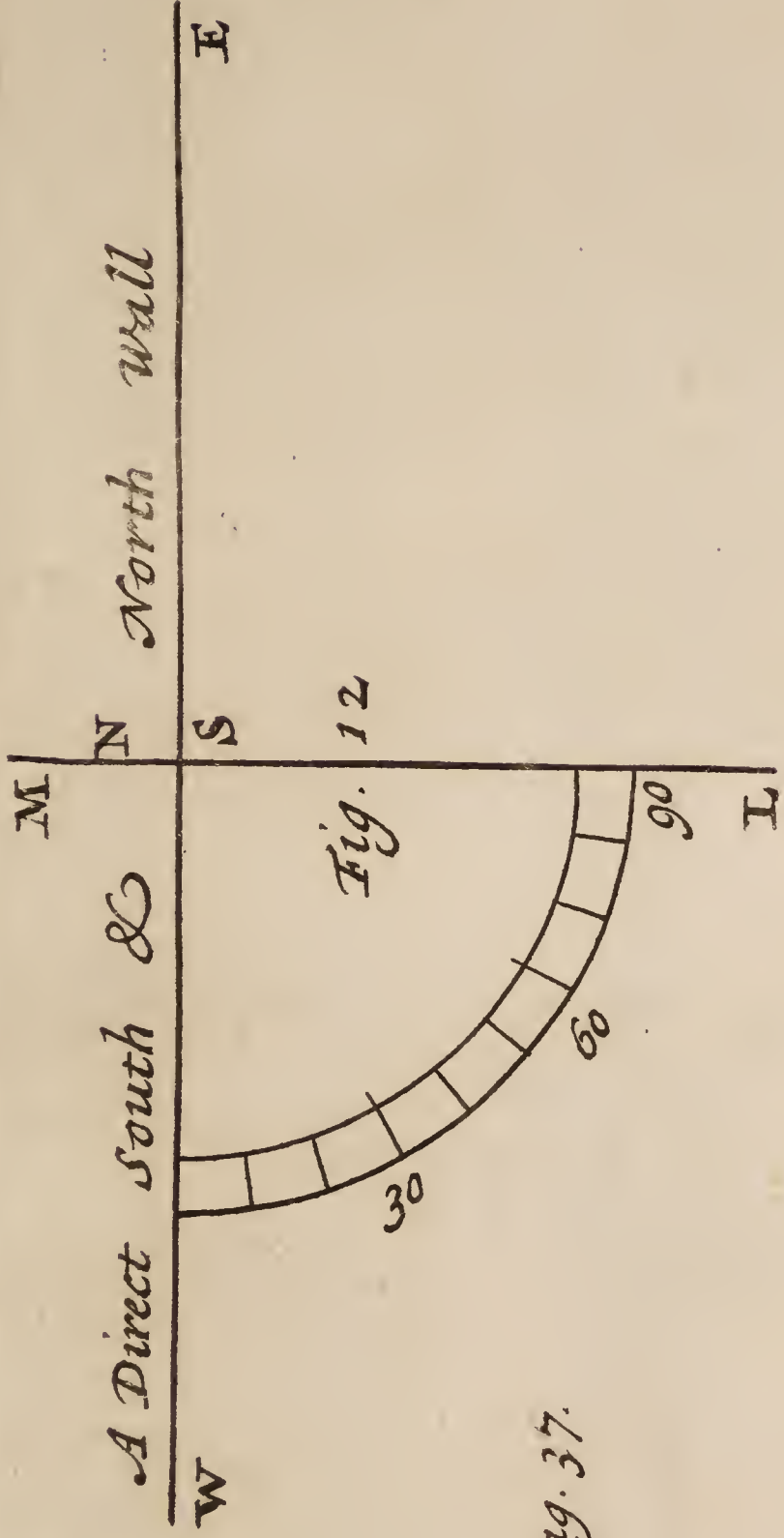
ther Direct or Declining) are more usually drawn on *Unmoveable* or Fixed Planes namely, on the Sides of some Wall. Wherefore in order to draw a Vertical Dial on a Wall, it is requisite first to know, whether the Wall be a direct East or West, North or South Wall, or a Declining Wall; and if the latter, how great its Declination is.

8.
To know
when a
Wall is
Direct,
East or
West,
North or
South.

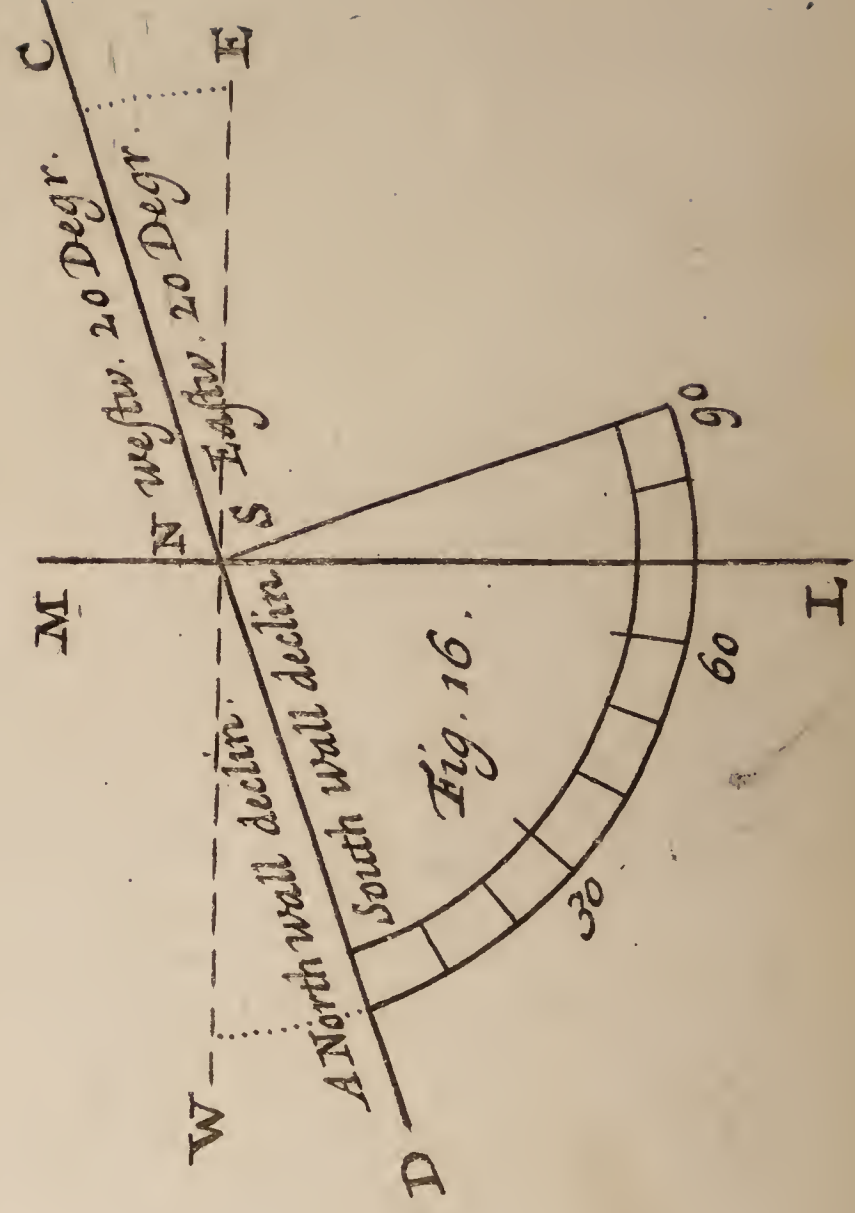
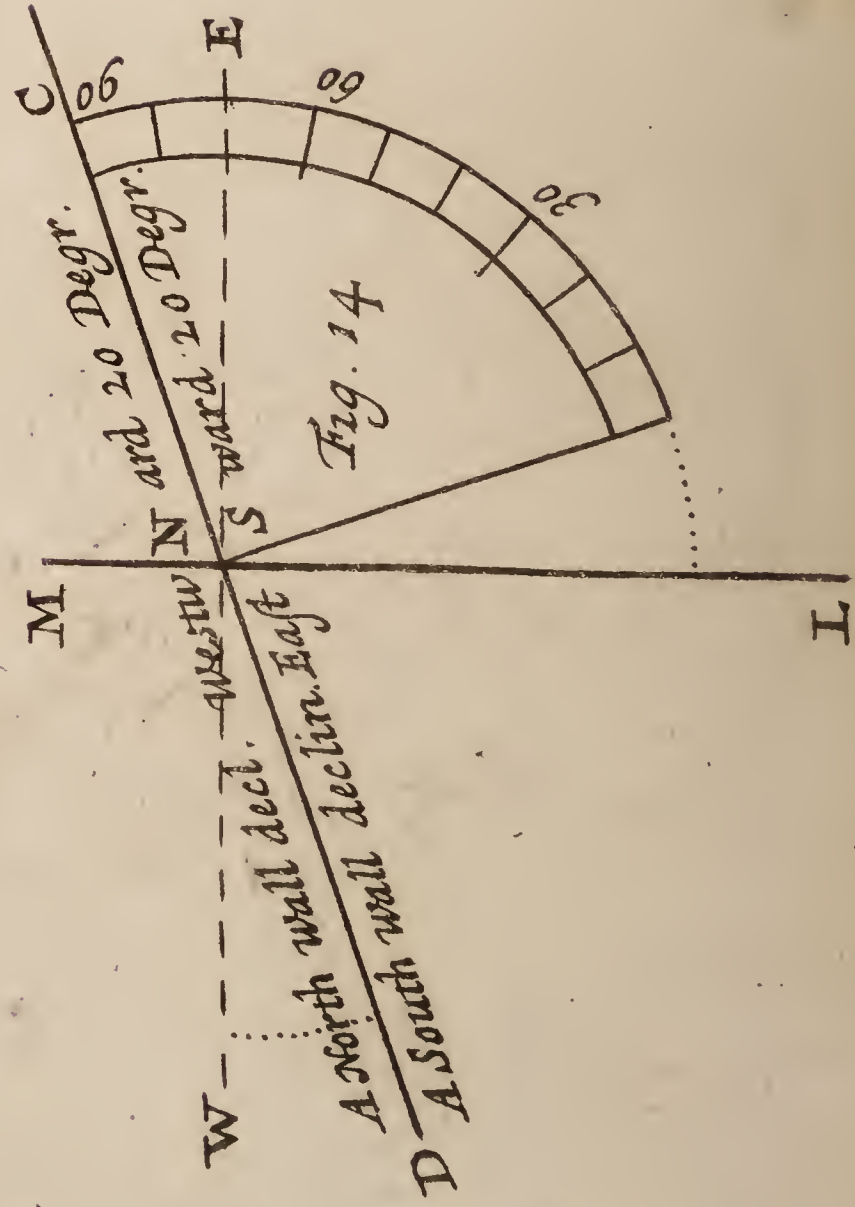
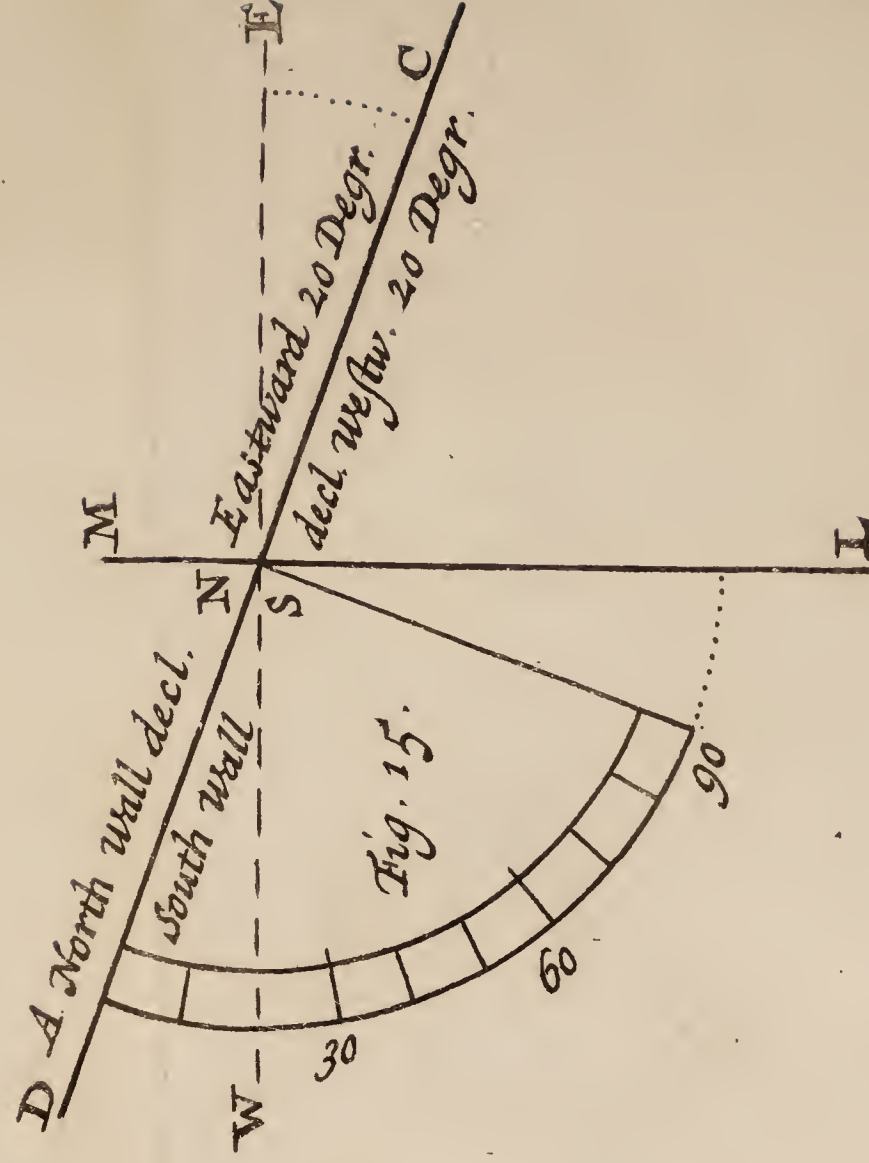
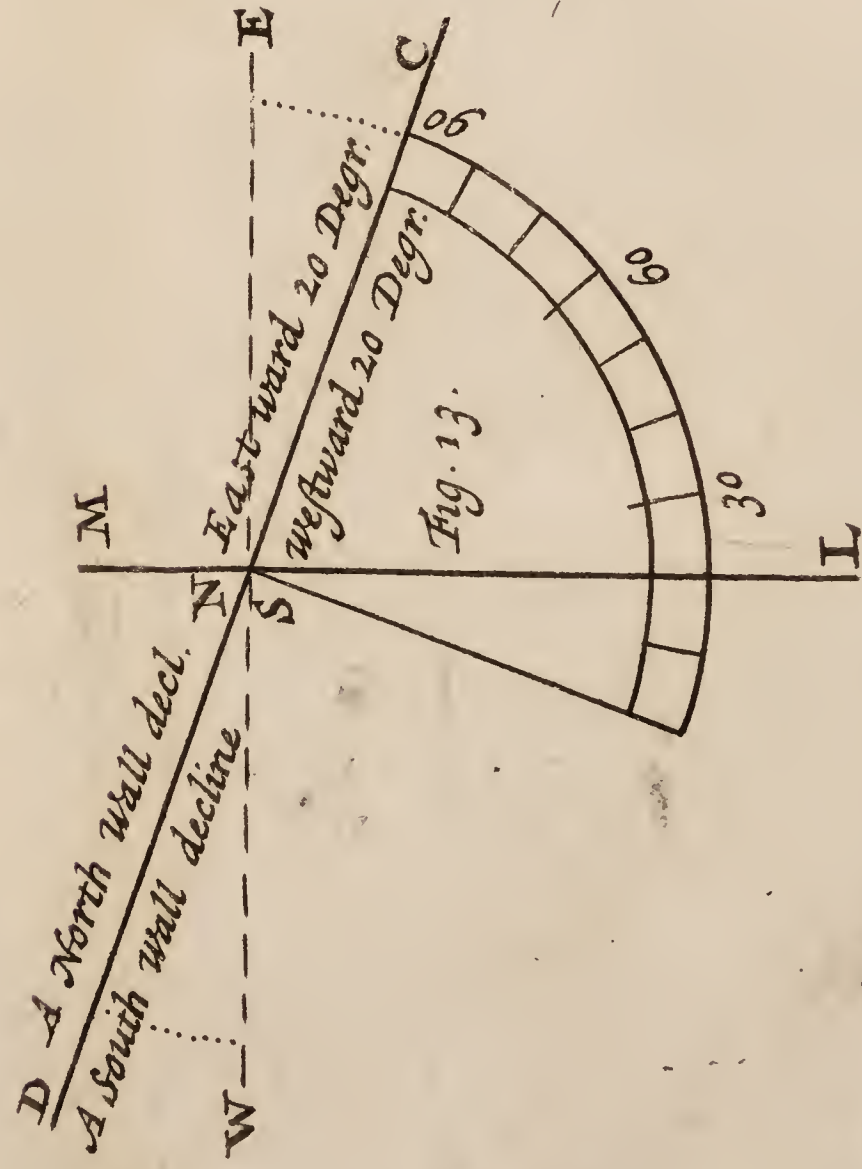
Now there are several Ways delivered in Treatises of Dialling for to do this; but such as require, either a peculiar Instrument called from its Use a *Declinator*, or else the Sun's *Azimuth* to be taken, or both. Wherefore I think the following Method is to be preferred before any other, on Account of its Easiness, and withal Exactness. To the Wall, whose Situation you would know, adjoin a Board so, as that one of its Sides may touch the Wall, and the Surface of the Board may lie *Horizontally*, and fast. Upon the Board thus prepared find the *Meridian* by the last of the three Ways above-mentioned, and draw a Line on the Board representing the same, which therefore



Dial. Plate 7.



Place this facing Pag. 37.



therefore we call the *Meridian* Line. If the *Meridian* Line falls in with, or runs Parallel to your Wall, then it is a direct East or West Wall. If not so, then lay a Quadrant flat upon the said Board, with one of its Sides or Edges applied to the Wall, and its Center at the same Time on the *Meridian* Line. If the other Side falls upon the *Meridian* Line drawn on the Board, then the Wall is a direct North and South Wall, *i. e.* that Side of the Wall which is toward the Sun and you, directly Faces the South; and the other Side of it consequently Faces directly the North. See *Fig. 12.*

But if when one Side of the Quadrant is applied to the Wall as afore,^{9.} the other Side does not fall upon the *Meridian* Line on the Board, then it ^{To know when a Wall declines.} is a declining Wall. And if when the right Side or Edge of the Quadrant is applied to the Wall, the *Meridian* Line of the Board is beyond, or without the other Side of the Quadrant, then the Wall in respect of its south Side declines Eastward, in respect of its north Side Westward, (as

Of Placing Dials.

(as *Fig. 14.*) but if the *Meridian* Line of the Board be within the left Side of the Quadrant, then the Wall in respect of its south Side declines Westward, in respect of its north Side Eastward, as *Fig. 13.* On the contrary, if the left Side or Edge of the Quadrant be applied to the Wall, and the *Meridian* Line on the Board be without the right Side of the Quadrant, then the Declination of the Wall in respect of its south Side is Westward, in respect of its north Side Eastward (as *Fig. 15.*): but if the said *Meridian* Line be within the right Side of the Quadrant then the Declination of the Wall in respect of its south Side is Eastward, and in respect of its north Side Westward, as *Fig. 16.*

10.
To find the
Degrees of
Declina-
tion.

Having thus found, whether the Wall declines Eastward or Westward, it remains to find, how great its Declination is. Now, as when, one Side of the Quadrant being duly applied (as afore) to the Wall, the other Side falls exactly upon the *Meridian* Line of the Board, the Wall has no Declination; so when the
other

Of finding the Situation of Walls.

39

other Side of the Quadrant does not fall exactly upon the said *Meridian* Line, then the Number of Degrees contained in the Angle made by the said other Side of the Quadrant, and the said *Meridian* Line is the Measure of the Declination. Wherefore as often as the said *Meridian* Line falls within the Quadrant, the Number of Degrees intercepted between the said *Meridian* Line, and that Side or Edge of the Quadrant which is not applied to the Wall, is the Measure of the Wall's Declination. But if the *Meridian* Line falls without the Quadrant, then having drawn on the Board a Circle, with a Ray equal to that of the Quadrant, and upon that Point of the *Meridian* Line whereon you place the Center of the Quadrant, as the Center of the said Circle, thereupon take with the Compasses the Distance between the *Meridian*, and that Edge of the Quadrant, which is not applied to the Wall: The said Distance applied to the Division of the Quadrant into 90 Degrees, will thereby shew the Measure of the Wall's Declination.

II.
Illustration
by Ex-
amples.

All that has been aforesaid, is illustrated by (*) Fig. 12, 13, 14, 15, and 16. In each of which the Line ML denotes the *Meridian Line*; the Line EW denotes the Plane of the Prime Vertical, or (which comes to the same) the Plane of a direct South Wall or Dial; and consequently E denotes the true East Point, W the true West Point. ESW the South Side of the Plane of the Prime Vertical, or a direct South Wall; ENW the north Side of the Plane of the Prime Vertical, or a direct North Wall: the Line DC denotes a declining Wall. Wherefore it is evident, that in Fig. 12. one Edge of the Quadrant being duly applied to EW the Wall, on the south Side of it ESW, the other will fall upon the *Meridian Line*, ML drawn on the Board; and thereby shew, that the said Wall EW has no Declination. But in Fig. 13. the right Edge

(*) From all these Figures it is evident, that the Declination of a Wall or Dial, is the Arch WD or EC of the *Horizon* intercepted between the Plane of the Prime Vertical, and of the Wall or Dial.

of the Quadrant being applied to D C the declining Wall, and the *Meridian* Line M L falling within the other Side of the Quadrant, thereby is shewn, that the Wall declines westward, and also that the Measure of the Declination is 20 Degrees, this being the Number of the Degrees intercepted between the left Side of the Quadrant, and the *Meridian* Line M L. In *Fig. 14.* the right Edge of the Quadrant being applied to D C the Wall, and the *Meridian* Line M L falling without the left Edge of the Quadrant, I take with my Compasses, on a Circle described as above directed, the Distance between M L the *Meridian* Line, and the left Edge of my Quadrant, and applying the same to the Division of the Quadrant into 90 Degrees, I find the Measure of the said Distance to be 20 Degrees; which consequently is the Measure of the Declination of the Wall D C eastward. And after the same Manner, the fore-mentioned Method of finding the Declination of a Wall may be illustrated in all other Respects.

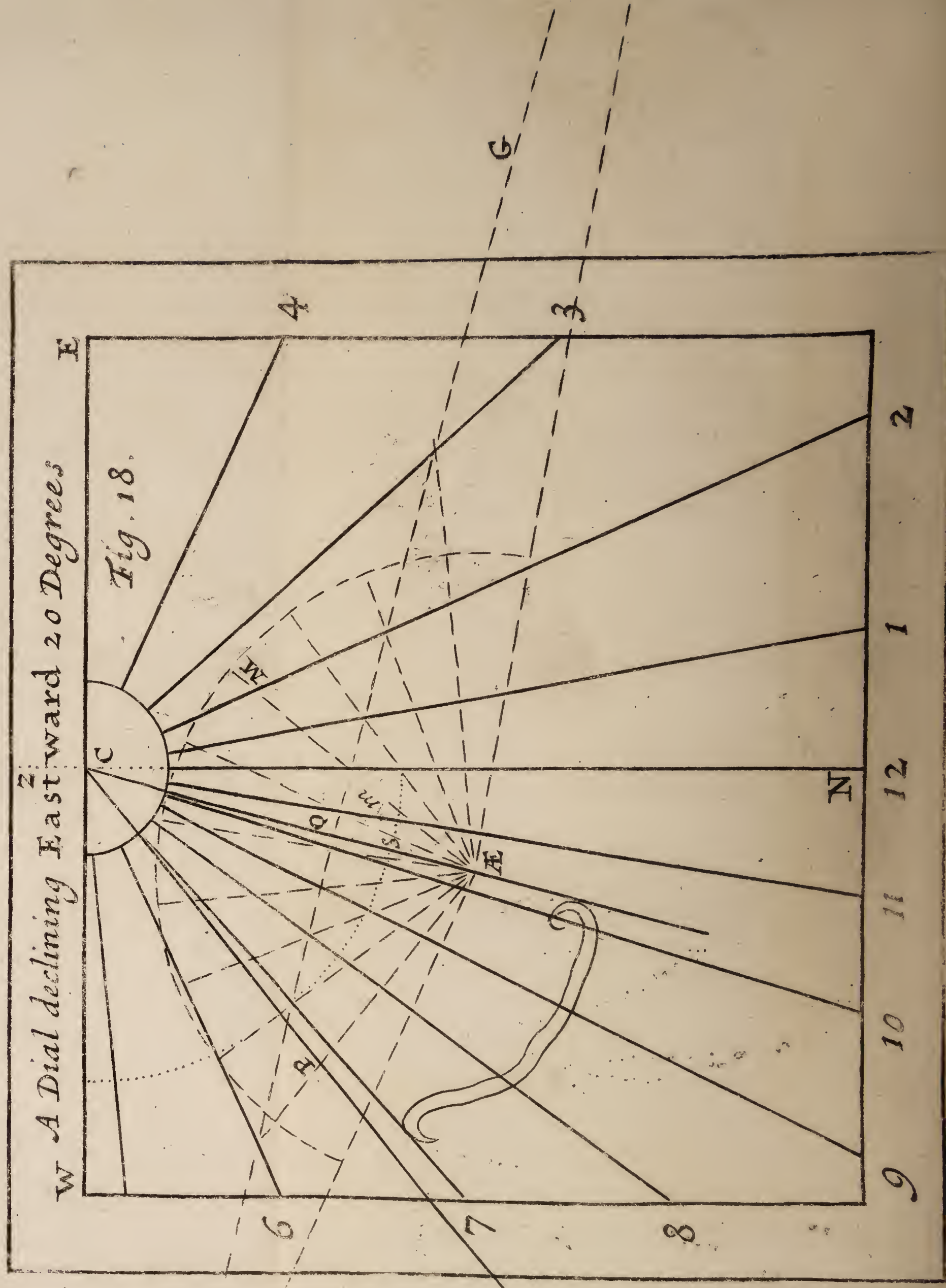
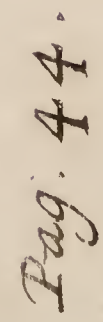
42 *Of finding the Declination, &c.*

Having thus shewn how to find the Declination of a Wall, it remains only to shew how to draw a Dial upon a declining Plane or Wall.

CHAP.



Place this
facing p. 43



CHAP. VI.

Of drawing a Declining Dial.

THE principal Difficulty in drawing a Declining Dial, is in finding the Distance of the Substyle from the *Meridian* or 12 a Clock Line, and the Height of the Style above the Substyle. Now to remove this Difficulty, there is adjoined to the End of this Chapter, a Table shewing the said Particulars, answerable to any Degree of Declination, and which will serve for most Parts of *England*.

I.
The chief
Difficulty
in drawing
a Declining
Dial.

Having then drawn (as in a Direct South or North Dial) two Lines crossing each other perpendicularly, one Z N representing the *Meridian*, the other E W representing the Prime Vertical; if you work by dialling-Tables, turn to the said Table (*viz.* Tab. III.) and see what is the Substyle's Distance from the *Meridian* answerable to the Declination of

2.
To find the
Substyle
and Style
of a Declining
Dial
by Dialling
Tables.

U 3 the

Of declining Dials.

the Wall, which, supposing the Declination 20 Degrees, will be 15 Degrees, 5 Minutes. Then draw an Arch from ZN to EW, on the west Side of ZN, if the Declination be eastward; and on the east Side, if the Declination be westward. On the said Arch set off from ZN the found Distance of the Substyle, *viz.* at S in *Fig.* 17 and 18. The Line CS, drawn from C (the Intersection of ZN and E W, and the Center of the Dial) to S, will be the Substyle. Then in the Table see what is the Style's Height answerable to the Declination, *v. g.* of 20 Degrees, and it is 35 Degrees, 34 Minutes. Set this off from S to P, and draw the Line CP which will shew the Style.

3.
To draw
the Hour-
Lines.

Having found the Substyle and the Style, draw (as afore in an *Horizontal*, and direct South or North Dial) the Contingent Line crossing the Substyle at right Angles in any Point Q: only the Substyle CS being here different from the *Meridian* ZN, mark the Point *m* of the *Meridian*, where

it

Of declining Dials.

45

it is crossed by the Contingent. Then taking (as afore in the other Dials) the Point Æ in the Substyle for the Center of an *Equinoctial* Dial, draw a (*) Semicircle; one Half of it being on one Side of the Substyle, and the other Half on the other Side. After which draw the Line ÆM cutting the *Equinoctial* Semicircle in M . The Line ÆM will be the *Meridian* of the *Equinoctial* Dial, from which you are to begin to divide on each Side the *Equinoctial* Semicircle into *Hours*, or six equal Parts. Lines drawn from Æ through the said Divisions to the Contingent will be the *Equinoctial*.

(*) It is to be observed, that in Declining Dials the entire Semicircle must be drawn; and it is not sufficient to draw only one Half of the Semicircle as in Direct South and North Dials, forasmuch as the *Meridian* or 12 a Clock Line of the *Equator*, not falling in with the *Meridian* or 12 a Clock Line of the Declining Dial, (as it does in Direct North and South Dials,) hence the Divisions on each Side the 12 a Clock Line of the *Equinoctial*, will not cut the Contingent at equal respective Distances, as in Direct North and South Dials.

U 4

Hours

Of declining Dials.

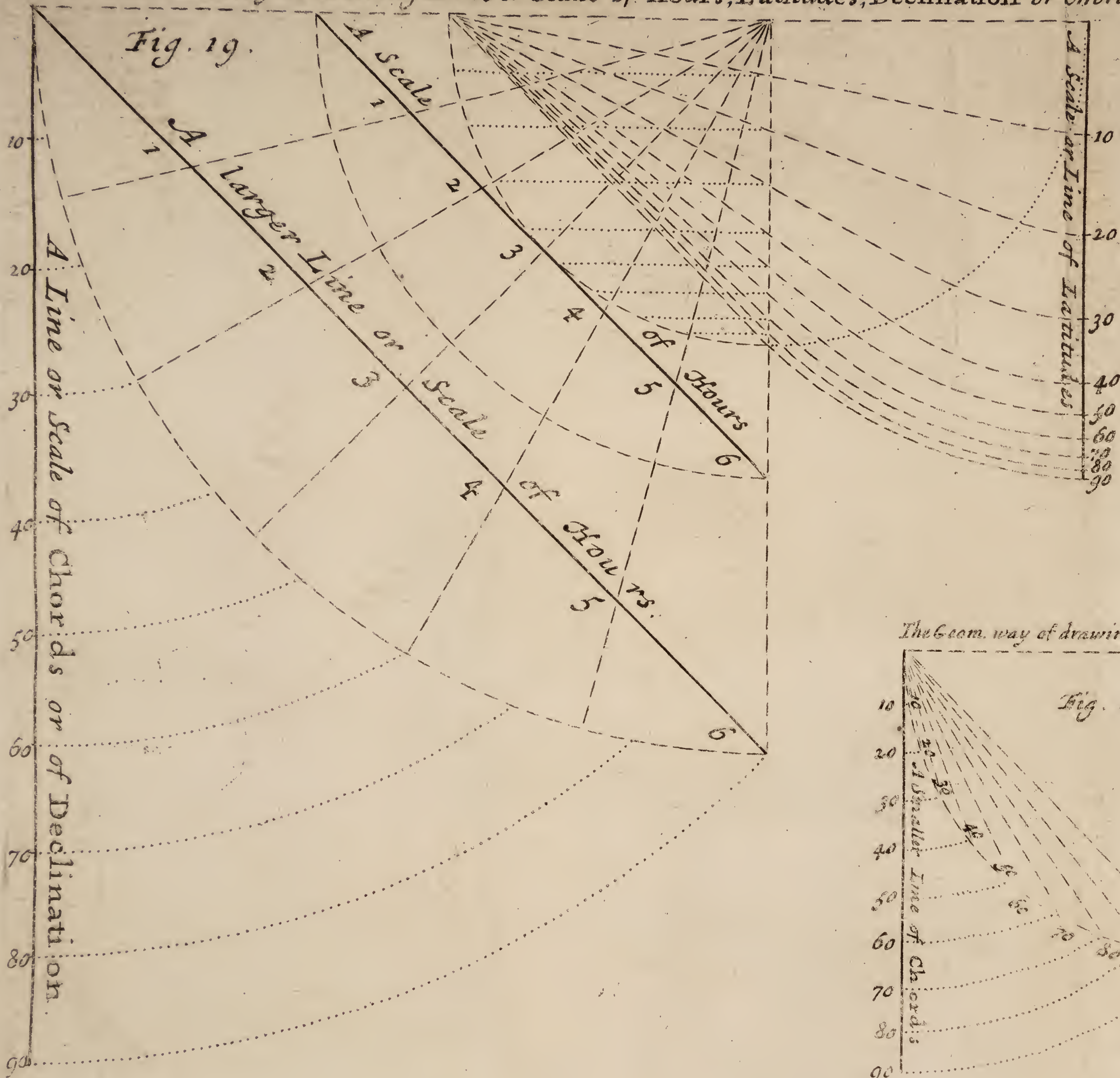
Hours. And consequently Lines drawn from C the Center of the declining Dial to the same Points of the Contingent, whereon the *Equinoctial* Hour-lines fall, will be the Hour-lines for the declining Dial, (as afore in an *Horizontal* and Direct North or South Dial,) and so the Dial will be finished. See *Fig. 17. and 18.*

4.
The Con-
clusion.

And thus I have gone through those Elements of Dialling, which I judge most requisite to be known by Young Gentlemen, at least at their first Institution in the said Art or Science. What follows, are such Dialling *Tables* as are requisite to this Treatise; which though calculated indeed for the Latitude of *Oxford*, (*viz.* 51 Degrees, 45 Minutes, yet will serve without any sensible Difference for most Parts of *England*. The Dialling *Scales*, or rather the Way of drawing Dialling Scales, *viz.* the Lines or Scales of *Latitude* and of *Hours*, (both mentioned and made use of in this Treatise) as also of *Inclination of Meridians*,

The Geometrical way of drawing Lines or Scales of Hours, Latitudes, Declination or Chords.

Fig. 19.

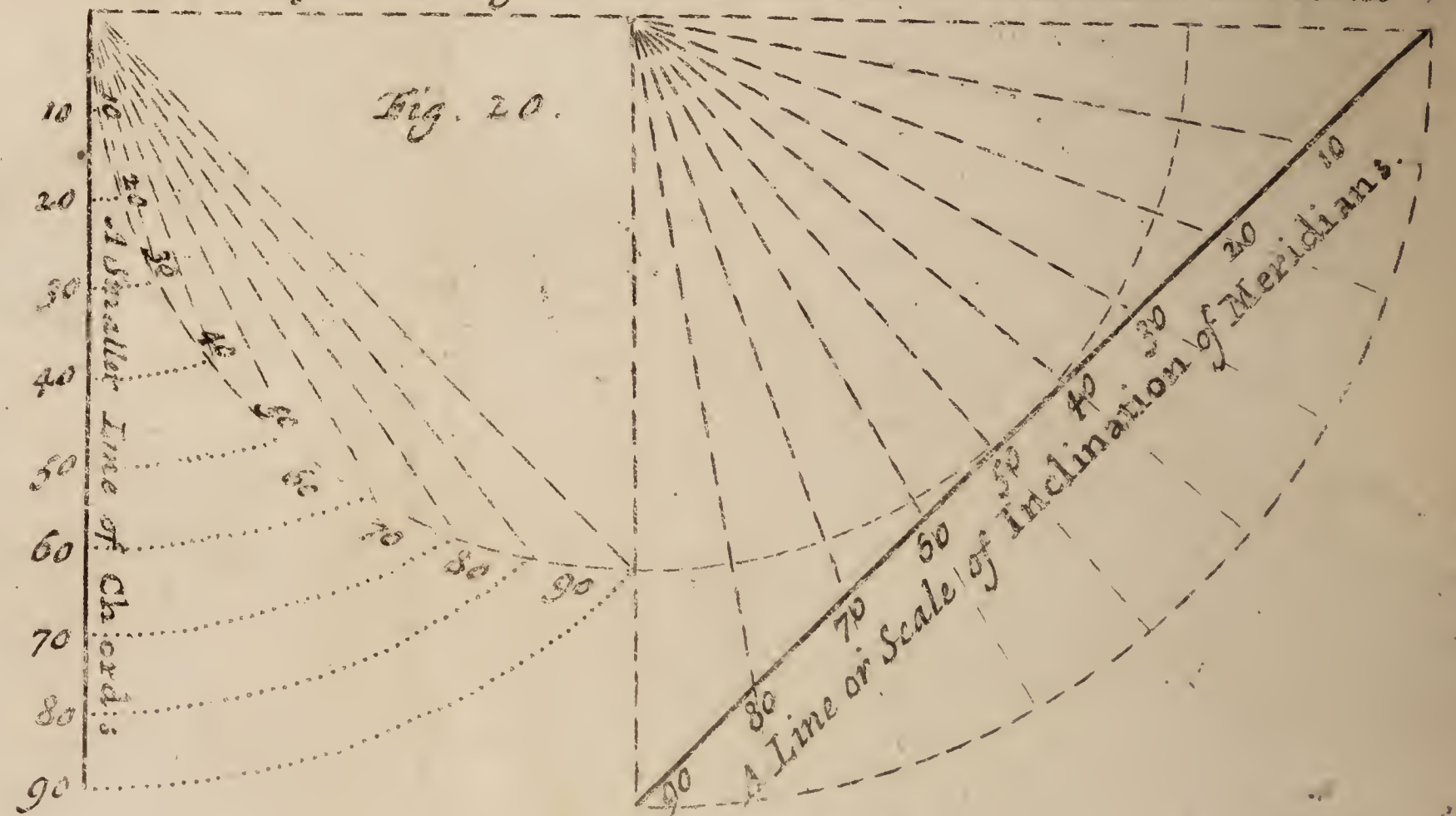


Dial. Plate 9.

Place this facing pag. 47.

The Geom. way of drawing a Scale of Inclination of Meridians & Chords.

Fig. 20.



Of declining Dials.

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Meridians, and of Declination (not mentioned in this Treatise, but put into all Dialling Scales) is represented Fig. 19. and 20.

T A B.

T A B. I.

Shewing what Angle every Hour-line, (as also Quarter, Half, and three Quarters of an Hour) makes with the *Meridian* or twelve a Clock Line, in an *Horizontal Dial*.

Hours.	Degree.	Minutes.
12	00 .	00 .
1	02 .	57 .
2	02 .	54 .
3	08 .	52 .
11	11 .	53 .
1	14 .	55 .
2	18 .	01 .
3	21 .	10 .
10 .	24 .	23 .
1	27 .	41 .
2	31 .	04 .
3	34 .	33 .
9 .	38 .	09 .
1	41 .	51 .
2	45 .	40 .
3	49 .	36 .
8 .	53 .	40 .
1	57 .	53 .
2	62 .	11 .
3	66 .	37 .
7 .	71 .	09 .
1	75 .	38 .
2	80 .	29 .
3	85 .	14 .
6 .	90 .	00 .

T A B. II.

Shewing the like Angles in a *Direct South* or *North Dial*.

Hours.	Degree.	Minutes.
12	00 .	00 .
1	02 .	19 .
2	04 .	40 .
3	07 .	01 .
11	09 .	25 .
1	11 .	52 .
2	14 .	23 .
3	16 .	58 .
10 .	19 .	40 .
1	22 .	28 .
2	25 .	24 .
3	28 .	30 .
9 .	31 .	46 .
1	35 .	13 .
2	38 .	54 .
3	42 .	49 .
8 .	47 .	00 .
1	51 .	27 .
2	56 .	13 .
3	61 .	15 .
7 .	66 .	36
1	72 .	11
2	77 .	00
3	83 .	58
6 .	90	00

T A B. III.

Shewing the *Distance of the Substyle* from the *Meridian*, and the *Height of the Style* above the Substyle, answerable to the several Degrees of *Declination*.

Declination.	Substyle's Distance from the <i>Meridian</i> .		Style's Height above the Substyle.	
Degrees.	Degrees.	Minutes.	Degrees.	Minutes.
I	0 .	47	38 .	14
2	1 .	34	38 .	13
3	2 .	21	38 .	11
4	3 .	8	38 .	8
5	3 .	55	38 .	5
6	4 .	42	38 .	0 .
7	5 .	28	37 .	55 .
8	6 ;	14	37 .	49
9	7 .	2	37 .	42
10	7 .	48	37 .	34

Decli

T A B. III.

Declination.	Substyle's Distance from the <i>Meridian</i> .		Style's Height above the Substyle.	
	Degrees.	Minutes.	Degrees.	Minutes.
11	8 .	33	37 .	26
12	9 .	18	37 .	16
13	10 .	2	37 .	6
14	10 .	48	36 .	55
15	11 .	32	36 .	43
16	12 .	15	36 .	31
17	12 .	59	36 .	18
18	13 .	41	36 .	2
19	14 .	24	35 .	50
20	15 .	5	35 .	34
21	15 .	47	35 .	19
22	16 .	27	35 .	2
23	17 .	7	34 .	44
24	17 .	47	34 .	26
25	18 .	15	34 .	8
26	19 .	4	33 .	49
27	19 .	41	33 .	29
28	20 .	19	33 .	8
29	20 .	55	32 .	47
30	21 .	31	22 .	25
31	22 .	6	32 .	3
32	22 .	40	31 .	40
33	23 .	14	31 .	17
34	23 .	47	30 .	53
35	24 .	19	30 .	28

Decl.

T A B. III.

Declination.	Substyle's Distance from the <i>Meridian</i> .		Style's Height above the Substyle.	
Degrees	Degrees.	Minutes.	Degrees.	Minutes.
36	24 .	52	30 .	3
37	25 .	23	29 .	36
38	25 .	53	29 .	12
39	26 .	23	28 .	45
40	26 .	52	28 .	18
41	27 .	21	27 .	51
42	27 .	49	27 .	23
43	28 .	16	26 .	55
44	28 .	42	26 .	26
45	29 .	8	25 .	57
46	29 .	33	25 .	29
47	29 .	58	24 .	58
48	30 .	22	24 .	28
49	30 .	45	23 .	58
50	31 .	8	23 .	27
51	31 .	30	22 .	56
52	31 .	51	22 .	24
53	32 .	12	21 .	52
54	32 .	32	21 .	20
55	32 .	51	20 .	48
56	33 .	10	20 .	15
57	33 .	28	19 .	42
58	33 .	46	19 .	9
59	34 .	3	18 .	35
60	34 .	19	18 .	2

Declination.

T A B. III.

Declination.	Substyle's Distance from the <i>Meridian</i> .		Style's Height above the Substyle.	
	Degrees.	Minutes.	Degrees.	Minutes.
61	34 .	35	17 .	28
62	34 .	50	16 .	54
63	35 .	5	16 .	19
64	35 .	19	15 .	45
65	35 .	32	15 .	10
66	35 .	46	14 .	35
67	35 .	58	14 .	0
68	36 .	10	13 .	44
69	36 .	21	12 .	49
70	36 .	32	12 .	13
71	36 .	42	11 .	38
72	36 .	51	11 .	2
73	37 .	1	10 .	26
74	37 .	9	9 .	34
75	37 .	17	9 .	13
76	37 .	25	8 .	37
77	37 .	22	8 .	9
78	37 .	37	7 .	24
79	37 .	44	6 .	47
80	37 .	50	6 .	10
81	37 .	54	5 .	41
82	37 .	59	4 .	57
83	38 .	2	4 .	19
84	38 .	6	3 .	43
85	38 .	9	3 .	5

T A B. III.

Declination.	Substyle's Distance from the Meridian.		Style's Height above the Substyle.	
Degrees.	Degrees.	Minutes	Degrees.	Minutes.
86	38 .	11	2 .	29
87	38 .	13	1 .	52
88	38 .	14	1 .	12
89	38 .	14	0 .	37
90	38 .	15	0 .	0

A CATALOGUE of the several Draughts of Dials, and other Cuts, belonging to this Treatise.

- Fig. 1. **A** *N* Horizontal Dial drawn by the Help of the Equinoctial Dial.
2. *An* Horizontal Dial drawn by the Help of dialling Scales.
3. *An* Horizontal Dial drawn by the Help of Dialling Tables.
4. *A* Direct South Dial drawn by the Help of the Equinoctial Dial.

5. *A*

A Catalogue, &c.

5. *A Direct South Dial drawn by the Help of Scales.*
6. *A Direct South Dial drawn by the Help of Tables.*
7. *A Direct North Dial.*
8. *A Direct East Dial.*
9. *A Direct West Dial.*
10. *The Draught of an Instrument, whereby to find, whether a Dial-plane be truly Horizontal, or Erect.*
11. *The Draught of the most exact Method for finding the Meridian of a Place or Dial-plane.*
- 12, 13, 14, 15, 16. *Several Draughts representing the Method to find whether a Wall be Direct or Declining; and if declining, how many Degrees it has of Declination.*
17. *A Dial declining Westward 26 Degrees.*
18. *A Dial declining Eastward 20 Degrees.*
19. *The Geometrical Way of drawing Lines, or Scales of Hours, of Latitudes, and also of Declination, or (which comes to the same) of Chords.*
20. *The Geometrical Way of drawing a Line or Scale of the Inclination of Meridians.*

F I N I S.

